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ASIA PUBLISHING HOUSE
BOMBAY • CALCUTTA • NEW DELHI • MADRAS
LUCKNOW • LONDON • NEW YORK

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1963

5.4.94
8115

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ALI

PRINTED IN INDIA

BY P. A. RAMAN AT INLAND PRINTERS, VICTORIA MILLS
BUILDINGS, 55 GAMDEVI ROAD, BOMBAY 7 AND PUBLISHED
BY P. S. JAYASINGHE, ASIA PUBLISHING HOUSE, BOMBAY 1.

FOREWORD

The vital role that general education can play in our universities is now being gradually recognized in academic circles. The Radhakrishnan Commission Report published in 1950, first emphasized the need for general education and made certain recommendations for its provision. The Ministry of Education organized conferences and seminars and drew the attention of universities towards its significance. A number of teachers and scholars drawn from various universities visited the United States and the United Kingdom to study the working of general education at various centres and to get first hand knowledge about the progress of various programmes of study. The University Grants Commission has now engaged the services of an expert to advise Indian Universities on the implementation of general education programmes and fifteen universities have already made these programmes a part and parcel of their regular course of studies.

Aligarh Muslim University was among the first to adopt a full and integrated programme of general education courses. Experience showed clearly the need for reading material to be especially prepared for the purpose of this new type of teaching which differs from the traditional one in method as well as in content. When approached, the University Grants Commission entrusted Aligarh Muslim University with the task of preparing reading material suitable for general education courses at Indian universities.

The series here presented, like general education itself, may not find agreement among all concerned. It is not meant to serve as a text which would be completely digested, let alone memorized or crammed. On the contrary it is intended to arouse curiosity, stimulate thinking and broaden the outlook of our students. The selections and samples are expected to enable students to use their intelligence and widen their understanding and appreciation. They may lead to a sense of values urgently needed today.

Another important and accepted aspect of general education is its complementary character. In our country, there is a great and urgent need for more people who are properly trained and educated to earn a living through performing competently the many functions on which our society depends. It is equally important, however, that colleges and universities also impart an education which enables students to live a fuller and more rewarding life. To quote the Report of the University Education Commission (pages 118-119): "The interests and opportunities and demands of life are not limited to any few subjects one may select to study. They cover the entire range of nature and of society. That is the liberal education which best enables one to live a full life, usually including an experience of mastery in some specialized field. . . ." To a student "a general education course should open windows in many directions, so that most of the varied experiences of his life and most elements of his environment, shall have meaning and interest to him."

The task, then, in preparing reading material for general education purposes was clear as well as complex. On the one hand, the mounting walls between the ever-increasing number of compartments of specialized knowledge had to be disregarded so that fragments could be re-assembled into that unity of knowledge which exists in human experience. On the other hand, it was necessary to present only so much of content as students in all traditional branches of knowledge could be expected to manage and to understand as an integrated whole. For, as Whitehead rightly remarked, "a student should not be taught more than he can think about."

Furthermore there is agreement that integration cannot be achieved by providing students with readymade opinions concerning questions that arise in the course of general education. On the contrary, if they are to be encouraged to think for themselves and to seek their own answers, they have to be confronted with errors of the past or doubts of the present, with divergent judgments or open alternatives, as well as with the beauty of scientific proof or the force of moral conviction.

The complete scheme of this series will be found on page ii where a systematic list of the publications is shown. While it adheres to the traditional division into Natural Sciences, Social Sciences and Humanities, many of the expository volumes straddle more than one field, and most of the source material touches upon problems not easily assigned to any one area only.

No student is likely to read and absorb all volumes; but every student will find instruction and inspiration in several of the volumes if he uses them properly under the guidance of his teachers. Large though the collection is, it cannot possibly aspire at complete comprehensiveness. Since "selection is the essence of teaching" (Whitehead) it had equally to be the principle of planning of this series. And since choice implies omission, many important disciplines had to be somewhat neglected, and others to be left out entirely. Unavoidably, what is here regarded as the result of careful consideration, may elsewhere appear as arbitrary.

The readers of these volumes, teachers and students alike, are the ones whom this publication wants to serve. From them, too, the authors, compilers, editors and advisers of this project hope to hear. It represents a co-operative effort in preparation and publication. Its success depends on further co-operation between "producers and consumers." Comments and criticisms are invited, to be addressed to: The Director, General Education Reading Material Project, Azad Library, Aligarh Muslim University, Aligarh. Since it is planned to translate the series into Hindi and Urdu, changes which may seem desirable, can easily be introduced when this is done.

In the end, the University acknowledges with gratitude the services rendered by the various contributors, reviewers, and the members of the Advisory Committee and all those due to whose keen interest and ready co-operation, the

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Directorate has been able to complete the Project. We are particularly grateful to the University Grants Commission who entrusted us with the task and assisted us liberally in this venture.

B. H. ZAIDI
Vice-Chancellor

Aligarh Muslim University,
1962

PREFACE

"The body of science," according to the Harvard Report on General Education, "includes not only special knowledge and skills but also conceptual interrelations, a world-view, and a view of the nature of man and knowledge, which together constitute the philosophy of science; a history which forms a continuous and important segment of all human history; and writings which include some of the most significant and impressive contributions to all literature."

Significant Writings on Life and Man, like its companion volume, *The Changing Concepts of the Universe,* seeks to present a world-view. Here Darwin expounds his revolutionary theory of the origin of species by natural selection and Oparin traces the origin of life. Haldane presents life as a unity in diversity while Julian Huxley takes care to emphasise the uniqueness of *Homo Sapiens*. This little book should give our readers a broader outlook on life and a clearer perspective of man's place in nature. It should certainly give them food for thought.

ACKNOWLEDGEMENTS

The Directorate is grateful to Mr. Moonis Raza and Mr. A. V. Jafri who compiled the selection, and to Prof. S. Sethna for reviewing the book.

The Directorate also expresses its gratitude to the following for permission to use extracts from their publications: Dr. Sergius Morgulius, College of Medicine, University of Nebraska, Omaha, U.S.A. for the English translation of Oparin's article; the author and the Publications Division, Government of India and the Director-General All India Radio, New Delhi for extract from Prof. J. B. S. Haldane's Patel Lectures; and to Chatto & Windus London for an extract from Prof. Huxley's work.

CONTENTS

Foreword v

Preface ix

Preliminaries 1

1. Charles Darwin

[From *The Origin of Species*] 5

2. A. I. Oparin

[From *The Origin of Life*] 24

3. J. B. S. Haldane

[From *The Unity of Life*] 30

4. Julian Huxley

[From *The Uniqueness of Man*] 43

PRELIMINARIES

MAN HAS always looked upon his ancestors as superior to himself. He traces his "descent" back to noble forebears. Charles Robert Darwin's (1809-82) theory of evolution was a veritable revolution in thought, for it linked man to apes. Society has always opposed new ideas; and this new theory was in conflict with religion and all established ideas.

If Copernicus had displaced the Earth from its central position so that it might become one of the planets, Darwin took man away from the company of angels so that he might recognise his cousins in the world of the living. The theory of special creation was discarded; variations and selection were held responsible for the development of species and for the evolution and emergence of man himself from lower beings. In an earlier era, Newton had brought heavenly bodies under the jurisdiction of terrestrial laws and disproved the Platonic and Aristotelian positions. Now Darwin, his countryman, was revolutionising human thought and presenting organic nature as a unity in diversity. Evolution had a far-reaching effect on sociology as well as in other fields of human knowledge.

Darwin's theory of evolution through natural selection proved the central unifying force in the field of biology. Little was known about fossils, organic evolution, and geographical variation of plants when this theory was first put forward. But later advances have confirmed the theory of natural selection, or the "survival of the fittest" and also developed it further. Evolution works through the processes of variation, selection and inheritance, and it is seen to occur in the living plants and animals.

Darwin's work has made easy the task of scientists who have to decide about species and varieties. The whole terminology of naturalists has received a new meaning. A new field of inquiry, "on the causes and laws of variation, on correlation, on the effects of use and disuse, on the direct action of external conditions, and so forth" has been opened up. A new light has been thrown on geological records and the geography of the past. The origin of man and his history are being reconstructed. In the long run Man's mental power and capacity will be controlled and moulded by gradations. Man will become conscious of the laws that operate in the world of life.

How did life originate? That has always been the first question in biology as well as in philosophy. Academician Alexander Oparin, Director of the Institute of Biochemistry of the Soviet Academy of Sciences, pioneered the study of the origin of life—of how, when and where "dead" matter was changed into living matter. Here was a new science which had to struggle for its existence since Darwin in an earlier age had remarked: "Talk of the origins of life? You might as well talk about the origin of elements!" The study of origin of life is based on a study of the Earth at the time when organic matter made its first appearance on it. This going back into time and reconstruction of a picture of the Earth of the past is possible only with assistance from astrophysicists. The atmosphere then consisted mainly of methane, ammonia and sulphuretted hydrogen at a temperature lower than 100°C. Laboratory experiments on the action of ultra-violet rays on such a mixture of gases have yielded free radicals and amines, amino acids and organic acids and carbohydrates. The organisation of these organic molecules into cells is a problem in bio-chemistry. The protoplasm is a sort of coazervate, only it is far more complex than an artificial one. "Sooner or later, somewhere in the primitive ocean various proteinic matters, drops of coazervate, must have separated from their watery solution. The formation of coazervate is an important step in the evolution of initial organic substance, leading to the origins of life." The first organisms were acellular. Cellular organisation came later. Evolution led to increasing complexity of structure. A detailed study of the structure of living beings and their evolution is imperative before life can be artificially produced through synthesis in the laboratory.

Whatever may have been the origin of organic matter there is a fundamental unity underlying all forms of life. Man should realise that animals and plants are his cousins, if rather distant ones. Animal minds are like human minds in that both possess consciousness. Animals manage to have some sort of a marriage ceremony. J. B. S. Haldane (1892-) has carried out very revealing experiments on mating between the male and the female of the little fly called *Drosophila subobscura.* Courtship among birds is full of song, dance and romance. Some of the smallest British birds are monogamous. Widows and widowers among larger birds do not generally marry again. Few of the animals domesticated by man are monogamous but for that man himself is to blame. "A bull who will not mate with any cow or a cow who will not mate with any bull is likely to be killed in Europe." Fish, too, have their "affairs". *Tilapia* mozambiquensis keeps its children in the security of its mouth. Fish can also recognise other individuals. The going-on of the bee among flowers leads one to conclude that "the love of the plant is the bee's aesthetic emotion, (and) the lust of the plant is the bee's hunger." Whether the behaviour of animals is instinctive or moral is immaterial; the fact stands that in many cases it is a model for us poor humans.

Animals may not possess language and intelligence as we do, but Prof. Haldane believes that the distinction between man and other animals is not absolute. Von Frisch's researches have proved that hive bees have their own language. Their signalling is very accurate, even by our standards. Bees have a highly organised socialistic pattern of society. Lindauer has found that it is a democratic society inspite of the queen; questions are decided by debate and persuasion without recourse to violence. (Have not the bees a message for militant groups of human beings?) In a country like ours animals should receive their due. Animal life is a fascinating field of study. Animals have their own place in our economy and we should learn to co-exist peacefully with them.

Most unsophisticated people have accepted the fact of man's obvious relationship with animals. Christian theology (inspite of St. Francis) and Descartes drew a clear dividing line between the two. Darwin reduced the gap, but the modern man "is beginning to see himself as a very peculiar and in many ways a unique animal." Man is unique in his capacity for conceptual thought—his employment of speech. It has resulted in the development of a cumulative tradition. Other higher animals have their elementary traditions but these are never cumulative. The cumulative tradition of man ensures the progressive improvement of tools and technique. Man lords it over other organisms by virtue of his traditions and tools. He is very much the crown of creation; certainly he is biologically dominant. Biologically speaking, he is the most variable species known. His mode of evolution is also unique. If animal evolution is divergent, human evolution is reticulate. Man's rate of development is abnormally slow. That is an advantage, for as Julian Huxley (1887-) points out, "If men and women were, like mice, confronted with the problems of adult life and parenthood after a few weeks or even, like whales, after a couple of years, they could never acquire the skills of body and mind that they now absorb from and contribute to the social heritage of the species. "Man's helplessness during the earliest years of life must have been a factor in the improvement of human intelligence. His rationality was helped by three other factors—birth of one child at a time, his early life on trees and his gregariousness. Fortunately for the human society, man, unlike most animals, is always linked to his partner by bonds of love. But he is always subject to psychological conflicts. He can master "pure mathematics, musical gifts, artistic appreciation and creation, religion (and) romantic love." As *Homo Sapiens* he should discharge his duties "in the hopefulness of tempered pride."

CHARLES DARWIN

Charles Robert Darwin (1809-82), the English naturalist, is well-known as the author of *The Origin of Species.* He was not particularly bright at Christ's College, Cambridge. Sir Charles Lyell's *Principles of Geology* profoundly influenced him when he embarked as a naturalist on the "Beagle" (1831-36) which was on a surveying expedition. He studied the geology of the countries that he visited. He attributed his success to "love of science, unbounded patience ... industry... and a fair share of invention as well as of commonsense." He had no prejudices to hamper his scientific work. He reflected long upon the problem of the modification of species, trying one idea after another. In 1838 he read *Malthus's On Population* and found that he had a theory to work on. Twenty years later A. R. Wallace sent him a manuscript which anticipated his own theory of evolution. The first edition of his classical work *On the Origin of Species by Means of Natural Selection,* or *the Preservation of Favoured Races in the Struggle for Life* (1859), was sold out the very first day it came out of the press.

Darwin's works include *Journal of a Naturalist; The Variation of Animals and Plants under Domestication; The Descent of Man and Selection in Relation to Sex; The Expression of Emotions; Formation of Vegetable Mould through the Action of Worms;* and *Fertilisation of Orchids.*

The Origin of Species starts with a study of artificial selection by man and natural selection as a result of the struggle for existence (4 chapters). Difficulties in the way of the new theory occupy five chapters. The last three deal with the evidence in support of evolution.

The extracts given below are reproduced from the original, without any departure from it in language, and order of presentation. Since it is a straight abridgement, material omitted has not been indicated by dots.

As this whole volume (*The Origin of Species*) is one long argument, it may be convenient to the reader to have the leading facts and inferences briefly recapitulated.

That many and serious objections may be advanced against the theory of descent with modification through variation and natural selection, I do not deny. I have endeavoured to give them their full force. Nothing at first can appear more difficult to believe than that the more complex organs and instincts have been perfected, not by means superior to, though analogous with, human reason, but by the accumulation of innumerable slight variations, each good for the individual possessor. Nevertheless, this difficulty, though appearing to our imagination insuperably great, cannot be considered real if we admit the following propositions: namely, that all parts of the organisation and instincts offer, at least, individual differences—that there is a struggle for existence leading to the preservation of profitable deviations of structure or instinct—and lastly, that gradations in the state of perfection of each organ may have existed, each good of its kind. The truth of these propositions cannot, I think, be disputed.

It is, no doubt, extremely difficult even to conjecture by what gradations many structures have been perfected, more especially amongst broken and failing groups of organic beings, which have suffered much extinction, but we see so many strange gradations in nature, that we ought to be extremely cautious in saying that any organ or instinct, or any whole structure, could not have arrived at its present state by many graduated steps. There are, it must be admitted, cases of special difficulty opposed to the theory of natural selection; and one of the most curious of these is the existence in the same community of two or three defined castes of workers of sterile female ants; but I have attempted to show how these difficulties can be mastered.

Although the fertility of varieties when intercrossed and of their mongrel offspring has been asserted by so many authors to be universal, this cannot be considered as quite correct after the facts given on the high authority of Garner and Kolreuter. Most of the varieties which have been experimented on have been produced under domestication; and as domestication (I do not mean mere confinement) almost certainly tends to eliminate that sterility which, judging from analogy, would have affected the parent-species if intercrossed, we ought not to expect that domestication would likewise induce sterility in their modified descendants when crossed. This elimination of sterility apparently follows from the same cause which allows our domestic animals to breed freely under diversified circumstances; and this again apparently follows from their having been gradually accustomed to frequent changes in their conditions of life.

A double and parallel series of facts seems to throw much light on the sterility of species, when first crossed, and of their hybrid offspring. On the one side, there is good reason to believe that slight changes in the conditions of life give vigour and fertility to all organic beings. We know also that a cross between the distinct individuals of the same variety, and between distinct varieties, increases the number of their offspring, and certainly gives to them increased size and vigour. This is chiefly owing to the forms which are crossed having been exposed to somewhat different conditions of life; for I have ascertained by a laborious series of experiments that if all the individuals of the same variety be subjected during several generations to the same conditions, the good derived from crossing is often much diminished or wholly disappears. This is one side of the case. On the other side, we know that species which have long been exposed to nearly uniform conditions, when they are subjected under confinement to new and greatly changed conditions, either perish, or if they survive, are rendered sterile, though retaining perfect health. This does not occur, or only in a very slight degree, with our domesticated productions, which have long been exposed to fluctuating conditions. Hence when we find that hybrids produced by a cross between two distinct species are few in number, owing to their perishing soon after conception or at a very early age, or if surviving that they are rendered more or less sterile, it seems highly probable that this result is due to their having been in fact subjected to a great change in their conditions of life, from being compounded of two distinct organisations.

Turning to geographical distribution, the difficulties encountered on the theory of descent with modification are serious enough. All the individuals of the same species, and all the species of the same genus, or even higher group, are descended from common parents; and therefore, in however distant and isolated parts of the world they may now be found, they must in the course of successive generations have travelled from some one point to all the others. We are often wholly unable even to conjecture how this could have been effected. Yet, as we have reason to believe that some species have retained the same specific form for very long periods of time, immensely long as measured by years, too much stress ought not to be laid on the occasional wide diffusion of the same species; for during very long periods there will always have been a good chance for wide migration by many means. A broken or interrupted range may often be accounted for by the extinction of the species in the intermediate regions. It cannot be denied that we are as yet very ignorant as to the full extent of the various climatal and geographical changes which have affected the earth during modern periods; and such changes will often have facilitated migration. As an example, I have attempted to show how potent has been the influence of the Glacial period on the distribution of the same and of allied species throughout the world. We are as yet profoundly ignorant of the many occasional means of transport.

As according to the theory of natural selection[1] an interminable number of intermediate forms must have existed, linking together all the species in each group by gradations as fine as are our existing varieties, it may be asked : Why do we not see these linking forms all around us ? Why are not all organic beings blended together in an inextricable chaos ? With respect to existing forms, we should remember that we have no right to expect (excepting in rare cases) to discover directly connecting links between them, but only between each and some extinct and supplanted form. Even on a wide area, which has during a long period remained continuous, and of which the climatic and other conditions of life change insensibly in proceeding from a district occupied by one species into another district occupied by a closely allied species, we have no just right to expect often to find intermediate varieties in the intermediate zones. For we have reason to believe that only a few species of a genus ever undergo change; the other species becoming utterly extinct and leaving no modified progeny. Of the species which do change, only a few within the same country change at the same time; and all modifications are slowly effected.

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[1] On "natural selection", a detailed discussion will be found in *The Story of Life*, General Education Reading Material Series No. 10.

Why does not every collection of fossil remains afford plain evidence of the gradation and mutation of the forms of life? Although geological research has undoubtedly revealed the former existence of many links, bringing numerous forms of life much closer together, it does not yield the infinitely many fine gradations between past and present species required on the theory; and this is the most obvious of the many objections which may be urged against it. Why, again, do whole groups of allied species appear, though this appearance is often false, to have come in suddenly on the successive geological stages? Although we now know that organic beings appeared on this globe, at a period incalculably remote, long before the lowest bed of the Cambrian system was deposited, why do we not find beneath this system great piles of strata stored with the remains of the progenitors of the Cambrian fossils?[2] For on the theory, such strata must somewhere have been deposited at these ancient and utterly unknown epochs of the world's history.

I can answer these questions and objections only on the supposition that the geological record is far more imperfect than most geologists believe. The number of specimens in all our museums is absolutely as nothing compared with the countless generations of countless species which have certainly existed. The parent-form of any two or more species would not be in all its characters directly intermediate between its modified offspring, any more than the rock-pigeon is directly intermediate in crop and tail between its descendants, the pouter and fantail pigeons. We should not be able to recognise a species as the parent of another and modified species, if we were to examine the two ever so closely, unless we possessed most of the intermediate links; and owing to the imperfection of the geological record, we have no just right to expect to find so many links. If two or three, or even more linking forms were discovered, they would simply be ranked by many naturalists as so many new species, more especially if found in different geological sub-stages, let their differences be ever so slight. Numerous existing doubtful forms could be named which are probably varieties; but who will pretend that in future ages so many fossil links will be discovered, that naturalists will be able to decide whether or not these doubtful forms ought to be called varieties? It is the dominant and widely ranging species which vary most frequently and vary most, and varieties are often at first local—both causes rendering the discovery of intermediate links in any one formation less likely. Local varieties will spread into other and distant regions until they are considerably modified and improved; and when they have spread, and are discovered in a geological formation, they appear as if suddenly created there, and will be simply classed as new species. Most formations have been intermittent in their accumulation; and their duration has probably been shorter than the average duration of specific forms. Successive formations are in most cases separated from each other by blank intervals of time of great length.

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[2] For a detailed discussion on this topic, please refer to *The Earth We Live On*, General Education Reading Material Series No. 9.

With respect to the lapse of time not having been sufficient since our planet was consolidated for the assumed amount of organic change, and this objection, as urged by Sir William Thompson, is probably one of the gravest as yet advanced, I can only say, firstly, that we do not know at what rate species change as measured by years, and secondly, that many philosophers are not as yet willing to admit that we know enough of the constitution of the universe and of the interior of our globe to speculate with safety on its past duration.

That the geological record is imperfect all will admit; but that it is imperfect to the degree required by our theory, few will be inclined to admit. If we look to long enough intervals of time, geology plainly declares that species have all changed, and they have changed in the manner required by the theory, for they have changed slowly and in a graduated manner. We clearly see this in the fossil remains from consecutive formations invariably being much more closely related to each other, than are the fossils from widely separated formations.

Such is the sum of the several chief objections and difficulties which may be justly urged against the theory; and I have now briefly recapitulated the answers and explanations which, as far as I can see, may be given. I have felt these difficulties far too heavily during many years to doubt their weight. But it deserves especial notice that the more important objections relate to questions on which we are confessedly ignorant; nor do we know how ignorant we are. Serious as these several objections are, in my judgment they are by no means sufficient to overthrow the theory of descent with subsequent modification.

Now let us turn to the other side of the argument. Under domestication we see much variability, caused, or at least excited, by changed conditions of life; but often in so obscure a manner, that we are tempted to consider the variations as spontaneous. Variability is governed by many complex laws, — by correlated growth, compensation, the increased use and disuse of parts, and the definite action of the surrounding conditions. There is much difficulty in ascertaining how largely our domestic productions have been modified; but we may safely infer that the amount has been large, and that modifications can be inherited for long periods.

Variability is not actually caused by man; he only unintentionally exposes organic beings to new conditions of life, and then nature acts on the organisation and causes it to vary. But man can and does select the variations given to him by nature, and thus accumulates them in any desired manner. This unconscious process of selection has been the great agency in the formation of the most distinct and useful domestic breeds. That many breeds produced by man have to a large extent the character of natural species, is shown by the inextricable doubts whether many of them are varieties or aboriginally distinct species.

There is no reason why the principles which have acted so efficiently under domestication should not have acted under nature. In the survival of favoured individuals and races, during the constantly-recurrent Struggle for Existence, we see a powerful and ever-acting form of Selection. The struggle for existence inevitably follows from the high geometrical ratio of increase which is common to all organic beings. This high rate of increase is proved by calculation, – by the rapid increase of many animals and plants during a succession of peculiar seasons, and when naturalised in new countries. More individuals are born than can possibly survive. A grain in the balance may determine which individuals shall live and which shall die, – which variety or species shall increase in number, and which shall decrease, or finally become extinct. As the individuals of the same species come in all respects into the closest competition with each other, the struggle will generally be most severe between them; it will be almost equally severe between the varieties of the same species, and next in severity between the species of the same genus. On the other hand the struggle will often be severe between beings remote in the scale of nature. The slightest advantage in certain individuals, at any age or during any season, over those with which they come into competition, or better adaptation in however slight a degree to the surrounding physical conditions, will, in the long run, turn the balance.

With animals having separated sexes, there will be in most cases a struggle between the males for the possession of the females. The most vigorous males, or those which have most successfully struggled with their conditions of life, will generally leave most progeny. But success will often depend on the males having special weapons, or means of defence, or charms; and a slight advantage will lead to victory.

As geology plainly proclaims that each land has undergone great physical changes, we might have expected to find that organic beings have varied under nature, in the same way as they have varied under domestication. And if there has been any variability under nature, it would be an unaccountable fact if natural selection had not come into play. It has often been asserted, but the assertion is incapable of proof, that the amount of variation under nature is a strictly limited quantity.

If then, animals and plants do vary, let it be ever so slightly or slowly, why should not variations or individual differences, which are in any way beneficial, be preserved and accumulated through natural selection, or the survival of the fittest? If man can by patience select variations useful to him, why, under changing and complex conditions of life, should not variations useful to nature's living products often arise, and be preserved or selected? The theory of natural selection, even if we look no farther than this, seems to be in the highest degree probable. I have already recapitulated, as fairly as I could, the opposed difficulties and objections: now let us turn to the special facts and arguments in favour of the theory.

As each species tends by its geometrical rate of reproduction to increase inordinately in number; and as the modified descendants of each species will be enabled to increase by as much as they become more diversified in habits and structure, so as to be able to seize on many and widely different places in the economy of nature, there will be a constant tendency in natural selection to preserve the most divergent offspring of any one species. Hence, during a long-continued course of modification, the slight differences characteristic of varieties of the same species, tend to be augmented into the greater differences characteristic of the species of the same genus. New and improved varieties will inevitably supplant and exterminate the older, less improved, and intermediate varieties; and thus species are rendered to a large extent defined and distinct objects. Dominant species belonging to the larger groups within each class tend to give birth to new and dominant forms; so that each large group tends to become still larger, and at the same time more divergent in character. But as all groups cannot thus go on increasing in size, for the world would not hold them, the more dominant groups beat the less dominant. This tendency in the large groups to go on increasing in size and diverging in character, together with the inevitable contingency of much extinction, explains the arrangement of all the forms of life in groups subordinate to groups, all within a few great classes, which has prevailed throughout all time. This grand fact of the grouping of all organic beings under what is called the Natural System, is utterly inexplicable on the theory of creation.

As natural selection acts by competition, it adapts and improves the inhabitants of each country only in relation to their co-inhabitants; so that we need feel no surprise at the species of any one country, although on the ordinary view supposed to have been created and specially adapted for that country, being beaten and supplanted by the naturalised productions from another land. Nor ought we to marvel if all the contrivances in nature be not, as far as we can judge, absolutely perfect, as in the case even of the human eye; or if some of them be abhorrent to our ideas of fitness.

The complex and little known laws governing the production of varieties are the same, as far as we can judge, with the laws which have governed the production of distinct species. In both cases physical conditions seem to have produced some direct and definite effect, but how much we cannot say. Thus, when varieties enter any new station, they occasionally assume some of the characters proper to the species of that station. With both varieties and species, use and disuse seem to have produced a considerable effect; for it is impossible to resist this conclusion when we look, for instance, at the longerheaded duck, which has wings incapable of flight, in nearly the same condition as in the domestic duck; or when we look at the burrowing tucu-tucu, which is occasionally blind, and then at certain moles, which are habitually blind and have their eyes covered with skin; or when we look at the blind animals inhabiting the dark caves of America and Europe. With varieties and species, correlated variation seems to have played an important part, so that when one part has been modified other parts have been necessarily modified. With both varieties and species, reversions to long-lost characters occasionally occur. How inexplicable on the theory of creation is the occasional appearance of stripes on the shoulders and legs of the several species of the horse-genus and of their hybrids! How simply is this fact explained if we believe that these species are all descended from a striped progenitor, in the same manner as the several domestic breeds of the pigeon are descended from the blue and barred rock-pigeon!

On the ordinary view of each species having been independently created, why should specific characters, or those by which the species of the same genus differ from each other, be more variable than generic characters in which they all agree? Why, for instance, should the colour of a flower be more likely to vary in any one species of a genus, if the other species possess differently coloured flowers, than if all possessed the same coloured flowers? If species are only well-marked varieties, of which the characters have become in a high degree permanent, we can understand this fact; for they have already varied since they branched off from a common progenitor in certain characters by which they have come to be specially distinct from each other. It is inexplicable on the theory of creation why a part developed in a very unusual manner in one species alone of a genus, and therefore, as we may naturally infer, of great importance to that species, should be eminently liable to variation; but, on our view, this part has undergone, since the several species branched off from a common progenitor, an unusual amount of variability and modification, and therefore we might expect the part generally to be still variable. But a part may be developed in the most unusual manner, like the wing of a bat, and yet not be more variable than any other structure, if the part be common to many subordinate forms, that is, if it has been inherited for a very long period; for in this case, it will have been rendered constant by long-continued natural selection.

If we admit that the geological record is imperfect to an extreme degree, then the facts, which the record does give, strongly support the theory of descent with modification. New species have come on the stage slowly and at successive intervals; and the amount of change, after equal intervals of time, is widely different in different groups. The extinction of species and of whole groups of species which has played so conspicuous a part in the history of the organic world, almost inevitably follows from the principle of natural selection; for old forms are supplanted by new and improved forms. Neither single species nor groups of species reappear when the chain of ordinary generation is once broken. The gradual diffusion of dominant forms, with the slow modification of their descendants, causes the forms of life, after long intervals of time, to appear as if they had changed simultaneously throughout the world. The fact of the fossil remains of each formation being in some degree intermediate in character between the fossils in the formation above and below, is simply explained by their intermediate position in the chain of descent. The grand fact that all extinct beings can be classed with all recent beings, naturally follows from the living and the extinct being the offspring of common parents. As species have generally diverged in character during their long course of descent and modification, we can understand why it is that the more ancient forms, or early progenitors of each group, so often occupy a position in some degree intermediate between existing groups. Recent forms are generally looked upon as being, on the whole, higher in the scale of organisation than ancient forms; and they must be higher, in so far as the later and more improved forms have conquered the older and less improved forms in the struggle for life; they have also generally had their organs more specialised for different functions. Lastly, the wonderful law of the long endurance of allied forms on the same continent, – of marsupials in Australia, of edentata in America, and other such cases, – is intelligible, for within the same country the existing and the extinct will be closely allied by descent.

Looking to geographical distribution, if we admit that there has been during the long course of ages much migration from one part of the world to another, owing to former climatal and geographical changes and to the many occasional and unknown means of dispersal, then we can understand, on the theory of descent with modification, most of the great leading facts in Distribution. We can see why there should be so striking a parallelism in the distribution of organic beings throughout space, and their geological succession throughout time; for in both cases the beings have been connected by the bond of ordinary generation, and the means of modification have been the same. We see the full meaning of the wonderful fact, which has struck every traveller, namely, that on the same continent, under the most diverse conditions, under heat and cold, on mountain and lowland, on deserts and marshes, most of the inhabitants within each great class are plainly related; for they are the descendants of the same progenitors and early colonists. On this same principle of former migration, combined in most cases with modification, we can understand, by the aid of the Glacial period, the identity of some few plants, and the close alliance of many others, on the most distant mountains, and in the northern and southern temperate zones; and likewise the close alliance of some of the inhabitants of the sea in the northern and southern temperate latitudes, though separated by the whole intertropical ocean. Although two countries may present physical conditions as closely similar as the same species ever require, we need feel no surprise at their inhabitants being widely different, if they have been for a long period completely sundered from each other; for as the relation of organism to organism is the most important of all relations, and as the two countries will have received colonists at various periods and in different proportions, from some other country or from each other, the course of modification in the two areas will inevitably have been different.

On this view of migration, with subsequent modification, we see why oceanic islands are inhabited by only few species, but of these, why many are peculiar or endemic forms.

The existence of closely allied or representative species in any two areas, implies, on the theory of descent with modification, that the same parent-forms formerly inhabited both areas; and we almost invariably find that wherever many closely allied species inhabit two areas, some identical species are still common to both. Wherever many closely allied yet distinct species occur, doubtful forms and varieties belonging to the same groups likewise occur. It is a rule of high generality that the inhabitants of each area are related to the inhabitants of the nearest source whence immigrants might have been derived. We see this in the striking relation of nearly all plants and animals of the Galapagos archipelago, of Juan Fernandez, and of the other American islands, to the plants and animals of the neighbouring American mainland; and of those of the Cape de Verde archipelago, and of the other African islands to the African mainland. It must be admitted that these facts receive no explanation on the theory of creation.

The fact, as we have seen, that all past and present organic beings can be arranged within a few great classes, in groups subordinate to groups, and with the extinct groups often falling in between the recent groups, is intelligible on the theory of natural selection with its contingencies of extinction and divergence of character. On these same principles we see how it is, that the mutual affinities of the forms within each class are so complex and circuitous. We see why certain characters are far more serviceable than others for classification; why characters derived from rudimentary parts, though of no service to the beings, are often of high classificatory value; and why embryological characters are often the most valuable of all. The real affinities of all organic beings, in contradistinction to their adaptive resemblances, are due to inheritance or community of descent. The Natural System is a genealogical arrangement, with the acquired grades of difference, marked by the terms, varieties, species, genera, families, & c.; and we have to discover the lines of descent by the most permanent characters whatever they may be and of however slight vital importance.

The similar framework of bones in the hand of man, wing of a bat, fin of the porpoise, and the leg of the horse, — the same number of vertebræ forming the neck of the giraffe and of the elephant, — and innumerable other such facts, at once explain themselves on the theory of descent with slow and slight successive modifications. The similarity of pattern in the wing and in the leg of a bat, though used for such different purpose, — in the jaws and legs of a crab, — in the petals, stamens, and pistils of a flower, is likewise, to a large extent, intelligible on the view of the gradual modification of parts or organs, which were aboriginally alike in an early progenitor in each of these classes. On the principle of successive variations not always supervening at an early age, and being inherited at a corresponding not early period of life, we clearly see why the embryos of mammals, birds, reptiles, and fishes should be so closely similar, and so unlike the adult forms. We may cease marvelling at the embryo of an air-breathing mammal or bird having branchial slits and arteries running in loops, like those of a fish which has to breathe the air dissolved in water by the aid of well-developed branchiæ.

Disuse, aided sometimes by natural selection, will often have reduced organs when rendered useless under changed habits or conditions of life; and we can understand on this view the meaning of rudimentary organs. But disuse and selection will generally act on each creature, when it has come to maturity and has to play its full part in the struggle for existence, and will thus have little power on an organ during early life; hence the organ will not be reduced or rendered rudimentary at this early age. The calf, for instance, has inherited teeth, which never cut through the gums of the upper jaw, from an early progenitor having well-developed teeth; and we may believe, that the teeth in the mature animal were formerly reduced by disuse, owing to the tongue and palate, or lips, having become excellently fitted through natural selection to browse without their aid; whereas in the calf, the teeth have been left unaffected, and on the principle of inheritance at corresponding ages have been inherited from a remote period to the present day.

I have now recapitulated the facts and considerations which have thoroughly convinced me that species have been modified, during a long course of descent. This has been effected chiefly through the natural selection of numerous successive, slight, favourable variations; aided in an important manner by the inherited effects of the use and disuse of parts; and in an unimportant manner, that is in relation to adaptive structures, whether past or present, by the direct action of external conditions, and by variations which seem to us in our ignorance to arise spontaneously. It appears that I formerly underrated the frequency and value of these latter forms of variation, as leading to permanent modifications of structure independently of natural selection. But as my conclusions have lately been much misrepresented, and it has been stated that I attribute the modification of species exclusively to natural selection, I may be permitted to remark that in the first edition of this work, and subsequently, I placed in a most conspicuous position – namely, at the close of the Introduction – the following words : "I am convinced that natural selection has been the main but not the exclusive means of modification." This has been of no avail. Great is the power of steady misrepresentation; but the history of science shows that fortunately this power does not long endure.

I see no good reason why the views given in this volume should shock the religious feelings of any one. It is satisfactory, as showing how transient such impressions are, to remember that the greatest discovery ever made by man, namely, the law of the attraction of gravity, was also attacked by Leibnitz, "as subversive of natural, and inferentially of revealed, religion." A celebrated author and divine has written to me that "he has gradually learnt to see that it is just as noble a conception of the Deity to believe that He created a few original forms capable of self-development into other and needful forms, as to believe that He required a fresh act of creation to supply the voids caused by the action of His laws."

It may be asked how far I extend the doctrine of the modification of species. The question is difficult to answer, because the more distinct the forms are which we consider, by so much the arguments in favour of community of descent become fewer in number and less in force. But some arguments of the greatest weight extend very far. All the members of whole classes are connected together by a chain of affinities, and all can be classed on the same principle, in groups sub-ordinate to groups. Fossil remains sometimes tend to fill up very wide intervals between existing orders.

Organs in a rudimentary condition plainly show that an early progenitor had the organ in a fully developed condition; and this in some cases implies an enormous amount of modification in the descendants. Throughout whole classes various structures are formed on the same pattern, and at a very early age the embryos closely resemble each other. Therefore I cannot doubt that the theory of descent with modification embraces all the members of the same great class or kingdom. I believe that animals are descended from at most only four or five progenitors, and plants from an equal or less number.

Analogy would lead me one step farther, namely, to the belief that all animals and plants are descended from some one prototype. But analogy may be a deceitful guide. Nevertheless all living things have much in common, in their chemical composition, their cellular structure, their laws of growth, and their liability to injurious influences.

When the views advanced by me in this volume, and by Mr. Wallace, or when analogous views on the origin of species are generally admitted, we can dimly foresee that there will be a considerable revolution in natural history. Systematists will be able to pursue their labours as at present; but they will not be incessantly haunted by the shadowy doubt whether this or that form be a true species. This, I feel sure and I speak after experience, will be no slight relief. The endless disputes whether or not some fifty species of British brambles are good species will cease. Systematists will have only to decide (not that this will

5.4.94

be easy) whether any form be sufficiently constant and distinct from other forms, to be capable of definition; and if definable, whether the differences be sufficiently important to deserve a specific name. This latter point will become a far more essential consideration than it is at present; for differences, however slight, between any two forms if not blended by intermediate gradations, are looked at by most naturalists as sufficient to raise both forms to the rank of species.

Hereafter we shall be compelled to acknowledge that the only distinction between species and well-marked varieties is, that the latter are known, or believed, to be connected at the present day by intermediate gradations, whereas species were formerly thus connected. Hence, without rejecting the consideration of the present existence of intermediate gradations between any two forms we shall be led to weigh more carefully and to value higher the actual amount of difference between them. It is quite possible that forms now generally acknowledged to be merely varieties may hereafter be thought worthy of specific names; and in this case scientific and common language will come into accordance. In short, we shall have to treat species in the same manner as those naturalists treat genera, who admit that genera are merely artificial combinations made for convenience. This may not be a cheering prospect; but we shall at least be free from the vain search for the undiscovered and undiscoverable essence of the term species.

The other and more general departments of natural history will rise greatly in interest. The terms used by naturalists, of affinity, relationship, community of type, paternity, morphology, adaptive characters, rudimentary and aborted organs, & c., will cease to be metaphorical, and will have a plain signification. When we no longer look at an organic being as a savage looks at a ship, as something wholly beyond his comprehension; when we regard every production of nature as one which has had a long history; when we contemplate every complex structure and instinct as the summing up of many contrivances, each useful to the possessor, in the same way as any great mechanical invention is the summing up of the labour, the experience, the reason, and even the blunders of numerous workmen; when we thus view each organic being, how far more interesting — I speak from experience — does the study of natural history become !

A grand and almost untrodden field of inquiry will be opened, on the causes and laws of variation, on correlation, on the effects of use and disuse, on the direct action of external conditions, and so forth. The study of domestic productions will rise immensely in value. A new variety raised by man will be a more important and interesting subject for study than one more species added to the infinitude of already recorded species. Our classifications will come to be, as far as they can be so made, genealogies; and will then truly give what may be called the plan of creation. The rules for classifying will no doubt become simpler when we have a definite object in view. We possess no pedigrees or armorial bearings; and we have to discover and trace the many diverging lines of descent in our natural genealogies, by characters of any kind which have long been inherited. Rudimentary organs will speak infallibly with respect to the nature of long-lost structures. Species and groups of species which are called aberrant, and which may fancifully be called living fossils, will aid us in forming a picture of the ancient forms of life. Embryology will often reveal to us the structure, in some degree obscured, of the prototype of each great class.

[From *THE ORIGIN OF SPECIES*]

A. I. OPARIN

ONE MUST FIRST of all categorically reject every attempt to renew the old arguments in favour of a sudden and spontaneous generation of life. It must be understood that no matter how minute an organism may be or how elementary it may appear at first glance it is nevertheless infinitely more complex than any simple solution of organic substances. It possesses a definite dynamically stable structural organization which is founded upon a harmonious combination of strictly co-ordinated chemical reactions. It would be senseless to expect that such an organization could originate accidentally in a more or less brief span of time from simple solution or infusions.

However, this need not lead us to the conclusion that there is an absolute and fundamental difference between a living organism and lifeless matter. Everyday experience enables one to differentiate living things from their non-living environment. But the numerous attempts to discover some specific "vital energies" resident only in organisms invariably ended in total failure, as the history of biology in the nineteenth and twentieth centuries teaches us.

That being the case, life could not have existed always. The complex combination of manifestations and properties so characteristic of life must have arisen in the process of evolution of matter. A weak attempt has been made in these pages to draw a picture of this evolution without losing contact with the ground of scientifically established facts.

The gaseous mass which had once separated from the sun, owing to a cosmic catastrophe, furnished the material out of which our planet was formed. Carbon together with other elements of the solar atmosphere passed into this gaseous mass which ultimately was destined to form our earth. Carbon is distinguished among all the chemical elements by its exceptional ability to form atomic associations, and is found invariably in all living things. Even at temperatures similar to those prevailing on the sun's surface its atoms are united in pairs, and on further cooling it tends to form molecules with even greater numbers of atoms. Therefore, in the process of formation of our planet from the original incandescent mass of gas, heavy clouds of carbon must have very quickly condensed into drops or even solid particles and entered the primitive nucleus of the earth in the form of a carbonaceous rain or snow. There the carbon came into immediate contact with the elements of heavy metals forming the nucleus, primarily with iron which constitutes such an essential component of the central core of our present earth.

Mixed with the heavy metals, the carbon reacted chemically as the earth gradually cooled off, whereby carbides were produced, which are the carbon compounds most stable at high temperatures. The crust of primary igneous rocks which were formed subsequently separated the carbides from the earth's atmosphere. The atmosphere at that period differed materially from our present atmosphere in that it contained neither oxygen nor nitrogen gas but was filled instead with superheated aqueous vapor. The crust separating the carbides from this atmosphere still lacked rigidity to resist the gigantic tides of the inner molten liquid mass, caused by the attractive forces of sun and moon. The thin layer or igneous rock would rupture during these tides and through the crevices so formed the molten liquid mass from the interior depths would spread over the earth's surface. The superheated aqueous vapor of the atmosphere coming in contact with the carbides reacted chemically giving rise to the simplest organic matter, the hydrocarbons, which in turn gave rise to a great variety of derivatives (alcohols, aldehydes, ketones, organic acids, etc.) through oxidation by the oxygen component of water. At the same time these hydrocarbons also reacted with ammonia which appeared at that period on the surface of the earth. Thus amides, amines and other nitrogenous derivatives originated.

Thus it came about, when our planet had cooled off sufficiently to allow the condensation of aqueous vapor and the formation of the first envelope of hot water around the earth, that this water already contained in solution organic substances, the molecules of which were made up of carbon, hydrogen, oxygen, and nitrogen. These organic substances are endowed with tremendous chemical potentialities, and they entered a variety of chemical reactions not only with each other but also with the elements of the water itself. As a consequence of these reactions complex, high-molecular organic compounds were produced similar to those which at the present time compose the organism of animals and plants. By this process also the biologically most important compounds, the proteins, must have originated.

At first these substances were present in the waters of seas and oceans in the form of colloidal solution. Their molecules were dispersed and uniformly distributed in the solvent, but entirely inseparable from the dispersing medium. But as the colloidal solutions of various substances were mixed new and special formations resulted, the so-called coazervates or semi-liquid colloidal gels. In this process organic substance becomes concentrated in definite spatial arrangements and separated from the solvent medium by a more or less distinct membrane. Inside these coazervates or gels the colloidal particles assume a definite position toward each other; in other words, the beginnings of some elementary structure appear in them. Each coazervate droplet acquires a certain degree of individuality and its further fate is now determined not only by the conditions of the external medium but also by its own specific internal physico-chemical structure. This internal structure of the droplet determined its ability to absorb with greater or less speed and to incorporate into itself organic substances dissolved in the surrounding water. This resulted in an increase of the size of the droplets, i.e. they acquired the power to grow. But the rate of growth depends upon the internal physico-chemical structure of a given colloidal system and is greater the more this is adapted for absorption and for the chemical transformation of the absorbed materials.

In such manner, a peculiar situation had arisen which may be described as the growth competition of coazervate gels. However, the physico-chemical structure of gels during growth did not remain unaltered but tended constantly to change owing to the addition of new substances, to chemical interaction, etc. These transformations could either result in a further perfection of the organization or, on the contrary, induce degradation and loss of structure. In other words, the process could bring about self-destruction and resolution of the coazervate droplet which was itself responsible for starting it. Only such changes in the structure of colloidal systems which enabled the gel to absorb dissolved substances more rapidly and thus to grow better, in other words only changes of a progressive kind, acquired importance for continued existence and development. A peculiar selective process had thus come into play which finally resulted in the origin of colloidal systems with a highly developed physico-chemical organization, namely, the simplest primary organisms.

This brief survey purports to show the gradual evolution of organic substance and the manner by which ever, newer properties, subject to laws of a higher order, were superimposed step by step upon the erstwhile simple and elementary properties of matter. At first there were the simple solutions of organic substances, whose behaviour was governed by the properties of their component atoms and the arrangement of those atoms in the molecular structure. But gradually as a result of growth and increased complexity of the molecules, new properties have come into being and a new colloid-chemical order was imposed upon the more simple organic chemical relations. These newer properties were determined by the spatial arrangement and mutual relationship of the molecules. Even this configuration of organic matter was still insufficient to give rise to primary living things. For this, the colloidal systems in the process of their evolution had to acquire properties of a still higher order, which would permit the attainment of the next and more advanced phase in the organization of matter. In this process biological orderliness already comes into prominence. Competitive speed of growth, struggle for existence and, finally, natural selection determined such a form of material organization which is characteristic of living things of the present time.

Natural selection has long ago destroyed and completely wiped off from the face of the earth all the intermediate forms of organization of primary colloidal systems and of the simplest living things and, wherever the external conditions are favourable to the evolution of life, we find countless numbers of fully developed highly organized living things. If organic matter would appear at the present time it could not evolve for very long because it would be quickly consumed and destroyed by the innumerable micro-organisms inhabiting the earth, water, and air. For this reason, the process of evolution of organic substance, the process of formation of life sketched in the preceding pages cannot be observed directly now. The tremendously long intervals of time separating the single steps in this process make it impossible to reproduce the process as it occurred in nature under available laboratory conditions.

There still remains, however, the problem of the artificial synthesis of organisms; but for its solution a very detailed knowledge of the most intimate, internal structure of living things is essential. Even the synthesis of comparatively simple organic combinations can be accomplished only when one possesses a more or less complete understanding of the atomic arrangement of their molecules. This, of course, would apply even more so in the case of such complex systems as organisms. We are still too far removed from such a comprehensive knowledge of the living organism to even dream of attempting their chemical synthesis. For the present research into the origin of life must, therefore, be restricted to studies of a purely analytical character.

We are faced with a colossal problem of investigating each separate stage of the evolutionary process as it was sketched here. We must delve into the properties of proteins, we must learn the structure of colloidal organic systems, of enzymes, of protoplasmic organization, etc. The road ahead is hard and long but without doubt it leads to the ultimate knowledge of the nature of life. The artificial building or synthesis of living things is a very remote, but not an unattainable, goal along the road.

[From *NEW WORLDS OF MODERN SCIENCE*
Dell Publishing Co. Inc., New York, 1956]

J. B. S. HALDANE

John Burdon Sanderson Haldane (1892-), FRS, is a scientist of international repute. He was educated at Eton and New College, Oxford. He served in the Army from 1914 to 1919. He was elected a fellow of his college and became Reader in Biochemistry at Cambridge University, Fullerian Professor of Physiology in the Royal Institution and Professor of Genetics and later of Biometry at the University of London. Scientific societies all over the world including the Société de Biologie, the Moscow Academy of Sciences, the Royal Danish Academy of Sciences and the National Institute of Sciences of India have heaped honours on him. He was awarded the Darwin Medal of the Royal Society, the Darwin Wallace Commemorative Medal of the Linnean Society, and the Feltrenilli Prize. Many universities have conferred honorary doctorates on him.

Besides serving as Chairman of the Editorial Board of the *Daily Worker*, Haldane has numerous scientific papers to his credit. His work on the origin of life has made him world-famous. His publications include *Possible Worlds; Animal Biology* (in collaboration with Julian Huxley); *Science and Ethics; Enzymes; The Inequality of Man; The Causes of Evolution; Heredity and Politics; The Marxist Philosophy and the Sciences; Science and Everyday Life; Science in Peace and War; New Paths in Genetics; A Banned Broadcast; Science Advances; Everything has a History;* and *The Biochemistry of Genetics.*

If we say, metaphorically, that all men are brothers, we mean, among other things, that they have common ancestors. We also mean that they are alike in their mental processes, and that therefore they have similar rights and duties.

If we say that all men are brothers, we can say that the animals and plants are our cousins, though rather distant ones. I think it is probable that if a man or woman who lived 1,00,000 years ago is the ancestor of any living man, he or she is the ancestor of us all. To find a common ancestor for a man and an insect we should have to go back about 7,000 times as far into the past; so the insects are pretty remote cousins. But does the metaphor mean any more than this? Can we find evidence that animal minds are like human minds? I shall try to show you that we can; I shall even try to convince you that the sexual reproduction of plants involves emotion.

We cannot prove that animals are conscious. But then I cannot prove that you are conscious. However I believe it. I also believe that a cow or a bird is conscious. We can however prove that animals have behaviour which we call moral or social when we find it in men. Marriage is one of the most fundamental of human institutions. It is found in all societies, though its forms vary, and most of us think that the kind of marriage prevalent in our own society is the best kind. Does it exist in animals? I define marriage as the association of a male and female, for economic as well as sexual purposes, *artha* as well as *kama*, preceded by a ceremony, and normally lasting at least until the children no longer need parental care. Clearly many animals do not marry in this sense. But even so some elements of human marriage may be found in unexpected quarters.

In my laboratory in London we used to breed a little fly, *Drosophila subobscura*, weighing less than a milligram. That is to say, 10 crores of these flies would weigh as much as a man. If you put a male and an unmated female together in a small glass tube they soon meet. The male stands in front of the female, and flicks his wings in a characteristic way. She then begins to dance with rapid movements to right and left. If the male can follow her motions and remain facing her for a minute or so, they usually kiss with the ends of their proboscides, and the female permits mating. But many males cannot dance adequately, and are kicked off if they try to mate.

In this species a female will never mate again on the same day. If she has not begun to lay fertile eggs she will mate again next day. But if she has once started laying fertile eggs she will hardly ever mate again, even after thirty days, which is about the equivalent of thirty years of human life, for these flies usually live more than a month but rarely as long as three months. The males, however, show no such fidelity. Clearly we have here some of the elements of marriage, but not perhaps the most important.

Marriage is seen at its best in birds. Our small English song birds have a fairly general pattern. Early in the spring a male bird occupies a territory by singing vigorously along its boundaries, and perhaps occasionally fighting intruding males. Females listen to the song, and look at the male and his property. If the female flies away the male does not chase her. If she stays he makes various songs and postures to the female and gives her food. This is often called courtship, but as we shall see, this phrase is misleading. After a period which is often of several weeks they build a nest. Usually both spouses build, but the hen may do it alone. When the nest is finished, the birds mate. But this does not generally occur till they have known one another for a month or so. When the eggs are laid the male may or may not help to keep them warm by day. He almost always does so at night. And he usually helps to feed the children when they hatch. During all this time of active family life the male generally continues to dance in front of the female and give her food. Some water birds give one another little presents of water weed which they do not eat, but seem to enjoy. As J. S. Huxley first pointed out, this behaviour can serve as courtship, but it also keeps a mated pair together and stabilizes the marriage. So of course, does comparable behaviour in human beings.

Most of our small British birds are monogamous. But Mr. Sálim Ali tells me that an industrious male Indian weaver bird may make several nests, and induce a different wife to live in each of them. The ladies do not, apparently, meet, so there are no quarrels between them.

Small European birds are mostly shortlived. Thus only about half the adult starlings (a bird similar to the mynah and of about the same size) living today will be alive in December of next year. Hence a survivor is as likely as not to be a widow or widower next year. So these small birds commonly marry afresh in each year of their lives. I do not shoot birds at any time, but it seems to me much worse to shoot ducks during the part of the year when they are married than during the remainder of it. A duck is certain to die some time. It may escape the sorrow caused by the death of its husband or wife. If you have ever watched a pair of ducks on a tank searching for one another after a few minutes' separation, you will hardly doubt that it is real sorrow.

Larger birds commonly marry for their joint lives, and it is not rare for widows or widowers to refuse to marry again. Some European species of lizard behave in this way. The widows, and particularly the widowers, attack other members of their species pretty savagely.

Mammals do not furnish such good examples of monogamy. They tend to group themselves in units larger than the family of two parents and their children. This is of course a step towards the evolution of society, but it is hard to reconcile it with monogamy. So we find the nearest approaches to the human ideal of marriage among not very social mammals such as tigers. This does not however mean that other wild mammals are quite promiscuous.

Now it is curious that in popular speech, at least in Europe, such words as "animalism" are used to mean sexual promiscuity. I think this is because few of our domestic animals are monogamous. The most nearly monogamous is the domestic pigeon. But there is no doubt that domestication has corrupted our cattle, sheep, and so on. A bull who will not mate with any cow or a cow who will not mate with any bull is likely to be killed in Europe. Even in India it will not be much used for breeding. So there is heavy selection against animals whose conduct approaches that of which we approve in men and women.

Now I want to defend fish. A few species of fish, especially of the family *Cichlidæ,* contract marriages after a fairly elaborate ceremonial courtship, and are usually faithful when offered a further choice of mates. This kind of behaviour is almost confined to fish living in lakes or slowly moving rivers, for a very obvious reason. A pair once separated in the ocean, or in a quickly moving river like the Jumna, are unlikely ever to meet again. In still water they may have their home in a bed of reeds, and learn their way back to it. Such fish do well in an aquarium provided one can find them mates whom they accept.

These still-water fish often look after their children. At the Fisheries Research Station at Cuttack I was shown a pair of *Tilapia mossambica,* a fresh-water fish of African origin which is bred in tanks in Indonesia, and whose introduction into India is being considered. One of the workers poked a fish with a stick, and it immediately spat out a hundred or so of its children from its mouth. If it had been caught, they might have escaped. It later took them into its mouth again, where of course they would have been safe from other fish. In some species both father and mother may protect their young in this way, and the parents' throats are often blocked by a growth of flesh after breeding, so that they cannot swallow their children accidentally. Casual observation of such fish has given rise to the legend that they breed from their mouths.

Other fish, for example Colisa, which is quite common in Bengal tanks, look after their young as follows. The male and female blow bubbles among the water plants. When the nest of bubbles is ready she lays eggs in it, and he fertilizes them. The father then guards this nest against animals which might eat the eggs, and when the young have hatched he guards them for some time.

Many fish move in shoals, and thus have at least a rudimentary social organisation. There is no evidence as yet that bees or other social insects can recognize other individuals, though they can tell a member of their own hive from that of another by its smell. But fish can do so. Göz trained a small fish to come for food when water, in which one and only one of twelve others had been swimming, was put into his jar. That is to say he knew other fish as individuals. This may be a basic difference between insect and vertebrate societies. And it is, I think, another refutation of *matsya nyaya,* and an argument in favour of those who object to killing and eating fish.

I have shown you, then, that some animals are models for human moral behaviour. We may say that their conduct is instinctive, not moral, behaviour. Perhaps the animals feel no desire to leave their spouse or eat their young. So much the better. We do not take human conjugal fidelity for granted. We do take it for granted that parents will die of hunger before eating their children, and we should severely blame any who ate them. It is not possible to draw a sharp line between instinctive conduct and moral conduct. But someone may say that even if animals have laudable instincts, they have nothing like human intelligence, and in particular nothing like human language which requires intelligence to use.

I have heard various public speakers speak of the great scientific discoveries of this century. In every case they referred to discoveries about the fine structure of matter, and usually drew the moral that they had been misused to make atomic bombs, and so on. I think that only two of the discoveries of this century in physics are of profound philosophical importance. One is Einstein's discovery that time and space are aspects of the same kind of relationship. The other is that the distinction between two particles of the same kind, such as electrons, is not absolute. We have not yet got the words to formulate this principle adequately. But it helps me to believe that the distinction between you and me, or the nearest mosquito and me, is nothing absolute either.

However, in my opinion the scientific discovery of the greatest philosophical importance was made by von Frisch. He discovered that hive bees have a language, and managed to understand at least some of it. His work was done on European bees, and as their languages differed slightly, there is little doubt that those of Indian bees will be found to be still more different. What I shall tell you may not all be true of Indian bees.

A beehive is a family whose mother, the so-called queen (but perhaps goddess would be a better metaphor) may live for some years. The workers only live for about six weeks in summer. The first three are spent on duties in the hive, the remainder in gathering food, and occasionally water and a kind of cement which is used in building. The foraging bees fall into two classes. About one in twenty looks for new sources of food; the others go where they are told. As all the bees in a hive are usually sisters, we do not know how the distinction arises.

If a bee has found a plentiful source of food, whether in flowers or in a dish of scented sugar water offered by a professor, within 50 yards of the hive, she flies back and dances round and round on the vertical surface of a honeycomb. Other bees follow her, smelling her back with their antennæ. If they are accustomed to visit flowers with the odour which they find on the dancer, they fly out in all directions, and look for a flower with this smell. A few may change over to a new flower, or fly out for the first time. These facts were discovered by marking individual bees with tiny spots of lacquer, and using a hive with a glass window. As soon as this was done, von Frisch found that, although a hive looks very busy, each individual bee spends a lot of time resting or gossiping with others. Few work for more than eight hours a day.

If the food is several hundred yards away the dance is quite different. It consists of straight runs in a certain direction, ending with a turn to right or left, and another run along the same path. During the run the bee waggles her abdomen. These dances were described by the Greek philosopher Aristotle 2200 years ago, but it was von Frisch who discovered that they were a language.

If the straight part of the dance is vertically upwards, this means that the food is in the direction of the sun. If it is 30 degrees to the right of the vertical, it means that the source is 30 degrees to the right of the sun, that is to say, in the northern hemisphere north of the tropics, usually to the west of the sun. The distance is signalled in two ways. The number of turns per minute goes down as the distance increases; and the number of abdominal waggles in each straight run increases by about one for each 75 yards of distance. However what is communicated is not distance, but time or effort. For the dance is slower, and more waggles are made, when the food source is up the wind or uphill.

How accurate is this signalling? The bees spread out a bit round the direction signalled, but the centre of the various directions is usually correct within two or three degrees. This means that the bees' communication is more precise than such a human phrase as "north east by north", but not so accurate as "17 degrees east of north". The distance is apparently judged correctly within 5 per cent or so. This again is very good by human standards. How many of you would say that a house is 530 yards along the road ? You would be quite content if you had said 500 or 600 yards.

But the most startling discovery of all was made by von Frisch's pupil Lindauer. When a hive becomes overpopulated, some of the bees leave it, usually with the old queen, while one of her daughters replaces her. The swarm may hang on a branch for several days. Bees fly out from it looking for a site for a new hive. When they have found one, perhaps in a hollow tree or in the roof of a house, they report back and signal the direction and distance by dancing on the swarm. Other bees fly out; and if they are satisfied, they signal the location to others. A bee may change its mind, or, if others do not agree with it, may retire from politics into the middle of the swarm. Lindauer gives the records of several debates of this kind which lasted for more than a day. Usually unanimity is reached. But a swarm may split in two. If so, the goddess goes off in one half, and the others follow her later.

This is, I think, a really great discovery. Here is a highly organized community with no private property. It is a socialistic society. But it is not a dictatorship or tyranny ruled by one individual. Nor does it show any signs of being ruled by a group soul, as theosophists hold. On the contrary, there is a diversity of opinions, and one of these finally prevails not by violence but by persuasion.

There are certainly other means of communication in the hive, including at least one by smell, but apparently no sounds. We do not yet know, for example, how bees cooperate to make the honey cells with the beautiful precision which is achieved, how they decide to swarm, how they regulate the temperature by bringing in water in hot weather, and many other things.

If bees observed human beings they might report something like this: "These large creatures are clearly very stupid, and have no real language. Many of their dances are crudely erotic. However, in Southern India some precision has been reached. But even here the *mudras* appear to signal emotions rather than facts. There is not the faintest evidence that they can communicate either direction or distance." By the way, you will have noticed that the two examples which I have chosen to demonstrate the similarity of animal and human minds both refer to social behaviour. This is not accidental, and is of some philosophical importance.

Please do not think I am arguing that animals are better or more intelligent than men. Some of them are better in some respects. But if the distinction between good and evil has any meaning, I do not think we can avoid the conclusion that some animal and plant species are evil. Parasitic worms, for example, cause the slow and often painful death of animals, including men, in which they live. And they have themselves lost the nervous system and sense organs which their ancestors almost surely possessed. Whereas the tiger, for example, kills quickly, and possesses beauty, intelligence, maternal love, and other good qualities. If we are to speak of the unity of life in the sense that we apply human criteria to other animals, we shall certainly find evidence of evil as well as good throughout the living world.

I consider it most important that Indians should take up the systematic study of animal behaviour. It can be of economic value, but I am thinking of its cultural value. In the past, Indians have been almost alone in refusing to eat animals, providing hospitals for sick animals, and so on. It is not my business to defend such attitudes. But I can say that they are very much more easily defended if they are based on scientific facts discovered in a careful study of animal behaviour. You have a few great observers of wild animals, such as Mr. Sálim Ali. There is room for thousands more. In particular the study of Indian bees requires no expensive apparatus. We know that they dance. We know very little more. In a country where the sun can be overhead it is hard to use it as a compass. But Lindauer found that bees in Ceylon could recognize a deviation of the sun from the zenith which he could not. In other words, though their eyes are not so efficient as ours, the *indriya,* or as I would put it, the nervous analyser, behind them, is more efficient.

Now I want to pass to another aspect of the unity of life, the co-operation between different species. The antagonism is obvious enough. Animals eat one another, besides eating plants. But the co-operation is usually between very different kinds of organisms. I shall just give two examples. When we speak of a rat we are apt to forget that the rat includes crores of bacteria with independent lives of their own, which live in its intestine. However it is possible to rear rats aseptically, with no bacteria in them. At most the bacteria provide some substances of which there may be a shortage in the rat's food. Probably a man could get on without bacteria, though again he would have to see that his diet was complete in certain respects. But a cow or a horse could not live on anything like their normal diets without bacteria and protozoa. A cow can live on grass. You and I cannot. Her digestive juices are not very unlike ours, but her stomach has several compartments, in some of which there are various kinds of single-celled organisms which help the cow to digest plant material which she could not use without them. Incidentally, they produce the pleasant smell which characterises the breath of a healthy cow. She spends a lot of time chewing the cud which she brings up from her stomach to her mouth, thus aiding the protozoa and bacteria in their work. Similarly, termites (white ants) cannot digest wood, but they contain protozoa which can do so.

We are much too apt to think of protozoa and bacteria as responsible for diseases such as malaria and cholera. Most of them are harmless. And they play an essential part in the cyclical changes which matter undergoes in the community of living organisms by converting dead plants and animals into chemical substances which the higher plants can absorb from the soil and make once more into living substance.

It is one thing to have one's digestion done for one by organisms of another species. It is much more remarkable to use another species to feel one's emotions. But consider flowers for a few minutes. They contain the sexual organs of plants. In the centre we usually find the stigma, a slightly moist surface which is the female external sexual organ, at the end of a pillar called the style. Round it are the male organs, the stamens which produce the pollen. When pollen is carried to the stigma the pollen grains burst, and microscopic tubes grow down from them into the female style, and finally fertilize the ovules in the ovary below it, which then become seeds. However the most conspicuous parts of a flower are usually the petals, which are commonly brightly coloured and highly scented. They may also be nectaries producing a sweet fluid. Every flower is a sexual symbol.

Many plants are self-sterile. Pollen from any one plant will not produce seeds on any of the flowers on it. What is more, a self-sterile plant is generally a member of a *gotra* no members of which can be crossed with other members. I use the word *gotra* not out of condescension to you, but because there is no English word for such a group. Membership of a *gotra* is determined both by the mother and father, and the discovery of the rules by which this is done was one of the most beautiful achievements of genetics. Even when plants are self-fertile they usually yield more seed, and more vigorous seedlings, if they are pollinated from another plant. This pollination is usually done by insects, which are attracted to flowers both by their colour, form, and odour, and their experience that they are sources of food.

Bees, butterflies, and many other insects are attracted by the bright colours of flowers and their regular shapes. A lot of work has been done with paper models, synthetic scents, and so on. It is clear that the aesthetic tastes of these insects are not very unlike our own, though bees can distinguish colours invisible to us in the ultraviolet, and cannot see red (or more accurately cannot distinguish it from dark grey). The vegetarian birds, or at least some of them, share these tastes. Other groups of animals have very different aesthetic preferences.

When a bee visits a flower, it finds certain colours, shapes, and odours satisfactory. It may also drink the sugary secretion of the flower, the so-called nectar, or gather some of its pollen to store in the comb. If it then visits another flower of the same species, it may leave some pollen in it, and cause a sexual union of the two plants which engenders one or more seeds. We may say that the love of the plant is the bee's aesthetic emotion, the lust of the plant is the bee's hunger. This point of view should not, I think, be quite novel to those who have read the *Yoga Vasistha* or the philosophy of Josiah Royce.

If a long-lived celestial being had visited our planet once in every ten million years or so, he would have seen the first trees some three hundred million years ago. They were like our tree-ferns, pines, and so on, and the herbs beneath them not unlike our ferns. The fertile parts of our planet were a rather monotonous green. Then in the Jurassic period, about 150 million years ago, flowers appeared, though they were at first very unlike most modern flowers. They became useful to the plants because of the psychological evolution of insects. The earth had put on new colours because there were at last animals which could appreciate them.

Somewhat later many plants developed fruits with bright colours and smelling not unlike the flowers. The birds and mammals ate them, but often carried the seeds for some distance. Thus although the plants cannot move, they can use animals, first to enable plants at a distance to mate with one another, and later, to allow their children to travel, and find new places to grow. It is not quite a metaphor to say that the monkey's pleasure in eating fruits is the mother-love of the fruit tree. All this co-operation is of course shot through with evil, or at least what appears to us men as evil so long as we can use this word meaningfully. Insects, for example, may eat the fruit without transporting the seeds. But it is nevertheless true that for a hundred million years or so the ancestors of the human race seem to have been co-operating with some of the higher plants, eating some of their fruits and seeds, and scattering others. Of course this co-operation was unconscious. As soon as it became conscious, agriculture started. But there had been a long preparation for it.

[From *THE UNITY AND DIVERSITY OF LIFE*, Patel Lecture delivered by J. B. S. Haldane, The Publication Division, Ministry of Information and Broadcasting, Government of India, Delhi, 1958]

JULIAN HUXLEY

SIR JULIAN HUXLEY (1887-   ) FRS, is a grandson of the famous Victorian biologist, T. H. Huxley. He was a King's scholar at Eton and Brakenbury scholar at the Balliol College, Oxford. He distinguished himself in studies as well as in athletics. He was a lecturer in zoology in his home college and from 1912 to 1916 a Research Associate and later an Assistant Professor at the Rice Institute at Houston, Texas (U.S.A.). He then returned to England where he held appointments at the Oxford University, King's College and the Royal Institution. He was the Founder-President of the Association of Scientific Workers and was also responsible for the birth of the Society of Experimental Biology, Association for Systematics and P.E.P. (Political and Economic Planning). To crown it all, he was appointed the first Director-General of UNESCO (1946-48).

Sir Julian is a very versatile writer. He won the Newdigate Prize for poetry at Oxford. He worked as adviser on the production of biological films. He has written on sociology, religion, philosophy, and many other subjects e.g., *The Individual in the Animal Kingdom; the Classical Evolution, the Modern Synthesis; Soviet Genetics and World Science; Evolution in Action; From an Antique Land;* and two volumes of essays, *New Bottles for New Wine,* and *The Uniqueness of Man.*

Huxley is well-known as a lecturer, broadcaster and author, who can make science intelligible to the layman. He is a humanist. He has expounded his ideas on evolutionary humanism in the introduction to *The Uniqueness of Man.* He pleads for a new basis for mankind's belief in itself—a belief "based on the concept of society as an organic whole, in which rights and duties are balanced deliberately. . . ."

MAN'S opinion of his own position in relation to the rest of the animals has swung pendulum-wise between too great or too little a conceit of himself, fixing now too large a gap between himself and the animals, now too small. The gap, of course, can be diminished or increased at either the animal or the human end. One can, like Descartes,[1] make animals too mechanical, or, like most unsophisticated people, humanize them too much. Or one can work at the human end of the gap, and then either dehumanize one's own kind into an animal species like any other, or superhumanize it into beings a little lower than the angels.

Primitive and savage man, the world over, not only accepts his obvious kinship with animals but also projects into them many of his own attributes. So far as we can judge, he has very little pride in his own humanity. With the advent of settled civilization, economic stratification, and the development of an elaborate religion as the ideological mortar of a now class-ridden society, the pendulum began slowly to swing into the other direction. Animal divinities and various physiological functions such as fertility gradually lost their sacred importance. Gods became anthropomorphic and human psychological qualities preeminent. Man saw himself as a being set apart, with the rest of the animal kingdom created to serve his needs and pleasure, with no share in salvation, no position in eternity. In western civilization this swing of the pendulum reached its limit in developed Christian theology and in the philosophy of Descartes: both alike inserted a qualitative and unbridgeable barrier between all men and any animals.

With Darwin, the reverse swing was started. Man was once again regarded as an animal, but now in the light of science rather than of unsophisticated sensibility. At the outset, the consequences of the changed outlook were not fully explored. The unconscious prejudices and attitudes of an earlier age survived, disguising many of the moral and philosophical implications of the new outlook. But gradually the pendulum reached the furthest point of its swing. What seemed the logical consequences of the Darwinian postulates were faced: man is an animal like any other; accordingly, his views as to the special meaning of human life and human ideals need merit no more consideration in the light of eternity (or of evolution) than those of a bacillus or a tapeworm. Survival is the only criterion of evolutionary success: therefore, all existing organisms are of equal value. The idea of progress is a mere anthropomorphism. Man happens to be the dominant type at the moment, but he might be replaced by the ant or the rat. And so on.

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[1] For a detailed note on Descartes and his Philosophy please refer *Man, Reality and Values* and *Readings in Philosophy*, General Education Reading Material Series Nos. 7 and 8.

The gap between man and animal was here reduced not by exaggerating the human qualities of animals, but by minimizing the human qualities of men. Of late years, however, a new tendency has become apparent. It may be that this is due mainly to the mere increase of knowledge and the extension of scientific analysis. It may be that it has been determined by social and psychological causes. Disillusionment with *laissez-faire* in the human economic sphere may well have spread to the planetary system of *laissez-faire* that we call natural selection. With the crash of old religious, ethical, and political systems, man's desperate need for some scheme of values and ideals may have prompted a more critical re-examination of his biological position. Whether this be so is a point that I must leave to the social historians. The fact remains that the pendulum is again on the swing, the man-animal gap again broadening. After Darwin, man could no longer avoid considering himself as an animal; but he is beginning to see himself as a very peculiar and in many ways a unique animal. The analysis of man's biological uniqueness is as yet incomplete. This essay is an attempt to review its present position.

The first and most obviously unique characteristic of man is his capacity for conceptual thought; if you prefer objective terms, you will say his employment of true speech, but that is only another way of saying the same thing. True speech involves the use of verbal signs for objects, not merely for feelings. Plenty of animals can express the fact that they are hungry; but none except man can ask for an egg or a banana. And to have words for objects at once implies conceptual thought, since an object is always one of a class. No doubt, children and savages are as unaware of using conceptual thought as Monsieur Jourdain was unaware of speaking in prose; but they cannot avoid it. Words are tools which automatically carve concepts out of experience. The faculty of recognizing objects as members of a class provides the potential basis for the concept: the use of words at once actualizes the potentiality.

This basic human property has had many consequences. The most important was the development of a cumulative tradition. The beginnings of tradition, by which experience is transmitted from one generation to the next, are to be seen in many higher animals. But in no case is the tradition cumulative. Off-spring learn from parents, but they learn the same kind and quantity of lessons as they, in turn, impart : the transmission of experience never bridges more than one generation. In man, however, tradition is an independent and potentially permanent activity, capable of indefinite improvement in quality and increase in quantity. It constitutes a new accessory process of heredity in evolution, running side by side with the biological process, a heredity of experience to supplement the universal heredity of living substance.

The existence of a cumulative tradition has as its chief consequence – or if you prefer, its chief objective manifestation – the progressive improvement of human tools and machinery. Many animals employ tools; but they are always crude tools employed in a crude way. Elaborate tools and skilled technique can develop only with the aid of speech and tradition.

In the perspective of evolution, tradition and tools are the characters which have given man his dominant position among organisms. This biological dominance is, at present, another of man's unique properties. In each geological epoch of which we have knowledge, there have been types which must be styled biologically dominant: they multiply, they extinguish or reduce competing types, they extend their range, they radiate into new modes of life. Usually at any one time there is one such type – the placental mammals, for instance, in the Cenozoic Epoch;[2] but sometimes there is more than one. The Mesozoic[3] is usually called the Age of Reptiles, but in reality the reptiles were then competing for dominance with the insects: in earlier periods we should be hard put to it to decide whether trilobites, nautiloids,[3] or early fish were the dominant type. To-day, however, there is general agreement that man is the sole type meriting the title. Since the early Pleistocene, widespread extinction has diminished the previously dominant group of placental mammals, and man has not merely multiplied, but has evolved, extended his range, and increased the variety of his modes of life.

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[2] A detailed discussion on the subject will be found in *The Earth We Live On*, General Education Reading Material Series No. 9.

Biology thus reinstates man in a position analogous to that conferred on him as Lord of Creation by theology. There are, however, differences, and differences of some importance for our general outlook. In the biological view, the other animals have not been created to serve man's needs, but man has evolved in such a way that he has been able to eliminate some competing types, to enslave others by domestication, and to modify physical and biological conditions over the larger part of the earth's land area. The theological view was not true in detail or in many of its implications; but it had a solid biological basis.

Speech, tradition, and tools have led to many other unique properties of man. These are, for the most part, obvious and well known, and I propose to leave them aside until I have dealt with some less familiar human characteristics. For the human species, considered as a species, is unique in certain purely biological attributes; and these have not received the attention they deserve, either from the zoological or the sociological standpoint.

In the first place, man is by far the most variable wild species known. Domesticated species like dog, horse, or fowl may rival or exceed him in this particular, but their variability has obvious reasons, and is irrelevant to our inquiry.

In correlation with his wide variability, man has a far wider range than any other animal species, with the possible exception of some of his parasites. Man is also unique as a dominant type. All other dominant types have evolved into many hundreds or thousands of separate species, grouped in numerous genera, families, and larger classificatory groups. The human type has maintained its dominance without splitting: man's variety has been achieved within the limits of a single species.

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[3] Refer to *Man, Reality and Values,* General Education Reading Material Series No. 7 for a detailed discussion of Psychological and Physiological problems of adjustment.

Finally, man is unique among higher animals in the method of his evolution. Whereas, in general, animal evolution is divergent, human evolution is reticulate. By this is meant that in animals, evolution occurs by the isolation of groups which then become progressively more different in their genetic characteristics, so that the course of evolution can be represented as a divergent radiation of separate lines, some of which become extinct, others continue unbranched, and still others divergently branch again. Whereas in man, after incipient divergence the branches have come together again, and have generated new diversity from their Mendelian recombinations, this process being repeated until the course of human descent is like a network.

All these biological peculiarities are interconnected. They depend on man's migratory propensities, which themselves arise from his fundamental peculiarities, of speech, social life, and relative independence of environment. They depend again on his capacity, when choosing mates, for neglecting large differences of colour and appearance which would almost certainly be more than enough to deter more instinctive and less plastic animals. Thus divergence, though it appears to have gone quite a long way in early human evolution, generating the very distinct white, black, and yellow sub-species and perhaps others, was never permitted to attain its normal culmination. Mutually infertile groups were never produced : man remained a single species. Furthermore, crossing between distinct types, which is a rare and extraordinary phenomenon in other animals, in him became normal and of major importance. According to Mendelian laws, such crosses generate much excess variability by producing new recombinations. Man is thus more variable than other species for two reasons. First, because migration has recaptured for the single interbreeding group divergences of a magnitude that in animals would escape into the isolation of separate species; and secondly, because the resultant crossing has generated recombinations which both quantitatively and qualitatively are on a far bigger scale than is supplied by the internal variability of even the numerically most abundant animal species.

We may contrast this with the state of affairs among ants, the dominant insect group. The ant type is more varied than the human type; but it has achieved this variability by intense divergent evolution. Several thousand species of ants are known, and the number is being added to each year with the increase of biological exploration. Ways of life among ants are divided among different sub-types, each rigidly confined to its own methods. Thus even if ants were capable of accumulating experience, there could exist no single world-wide ant tradition. The fact that the human type comprises but one biological species is a consequence of his capacity for tradition, and also permits his exploitation of that unique capacity to the utmost.

Let us remind ourselves that superposed upon this purely biological or genetic variability is the even greater amount of variability due to differences of upbringing, profession, and personal tastes. The final result is a degree of variation that would be staggering if it were not so familiar. It would be fair to say that, in respect to mind and outlook, individual human beings are separated by differences as profound as those which distinguish the major groups of the animal kingdom. The difference between a somewhat sub-normal member of a savage tribe and a Beethoven or a Newton is assuredly comparable in extent with that between a sponge and a higher mammal. Leaving aside such vertical differences, the lateral difference between the mind of a distinguished general or engineer of extrovert type and of an introvert genius in mathematics or religious mysticism is no less than that between an insect and a vertebrate. This enormous range of individual variation in human minds often leads to misunderstanding and even mutual incomprehensibility; but it also provides the necessary basis for fruitful division of labour in human society.

Another biological peculiarity of man is the uniqueness of his evolutionary history. Writers have indulged their speculative fancy by imagining other organisms endowed with speech and conceptual thought – talking rats, rational ants, philosophic dogs, and the like. But closer analysis shows that these fantasies are impossible. A brain capable of conceptual thought could not have been developed elsewhere than in a human body.

The course followed by evolution appears to have been broadly as follows. From a generalized early type, various lines radiate out, exploiting the environment in various ways. Some of these comparatively soon reach a limit to their evolution, at least as regards major alteration. Thereafter they are limited to minor changes such as the formation of new genera and species. Others, on the other hand, are so constructed that they can continue their career, generating new types which are successful in the struggle for existence because of their greater control over the environment and their greater independence of it. Such changes are legitimately called "progressive." The new type repeats the process. It radiates out into a number of lines, each specializing in a particular direction. The great majority of these come up against dead ends and can advance no further: specialization is one-sided progress, and after a longer or shorter time, reaches a biomechanical limit. The horse stock cannot reduce its digits below one; the elephants are near the limits of size for terrestrial animals; feathered flight cannot become aerodynamically more efficient than in existing birds, and so on.

Sometimes all the branches of a given stock have come up against their limit, and then either have become extinct or have persisted without major change. This happened, for instance, to the echinoderms, which with their sea-urchins, starfish, brittle-stars, sea-lilies, sea-cucumbers, and other types now extinct had pushed the life that was in them into a series of blind alleys: they have not advanced for perhaps a hundred million years, nor have they given rise to other major types.

In other cases, all but one or two of the lines suffer this fate, while the rest repeat the process. All reptilian lines were blind alleys save two – one which was transformed into the birds, and another which became the mammals. Of the bird stock, all lines came to a dead end; of the mammals, all but one – the one which became man.

Evolution is thus seen as an enormous number of blind alleys, with a very occasional path of progress. It is like a maze in which almost all turnings are wrong turnings. The goal of the evolutionary maze, however, is not a central chamber, but a road which will lead definitely onwards.

If now we look back upon the past history of life, we shall see that the avenues of progress have been steadily reduced in number, until by the Pleistocene period, or even earlier, only one was left. Let us remember that we can and must judge early progress in the light of its latest steps. The most recent step has been the acquisition of conceptual thought, which has enabled man to dethrone the non-human mammals from their previous position of dominance. It is biologically obvious that conceptual thought could never have arisen save in an animal, so that all plants, both green and otherwise, are at once eliminated. As regards animals, I need not detail all the early steps in their progressive evolution. Since some degree of bulk helps to confer independence of the force of nature, it is obvious that the combination of many cells to form a large individual was one necessary step, thus eliminating all single-celled forms from such progress. Similarly, progress is barred to specialized animals with no blood system like planarian worms; to internal parasites, like tapeworms; to animals with radial symmetry and consequently no head, like echinoderms.

Of the three highest animal groups – the molluscs, the arthropods, and the vertebrates – the molluscs advanced least far. One condition for the later steps in biological progress was land life. The demands made upon the organism by exposure to air and gravity called forth biological mechanisms, such as limbs, sense-organs, protective skin, and sheltered development, which were necessary foundations for later advance. And the molluscs have never been able to produce efficient terrestrial forms: their culmination is in marine types like squid and octopus.

The arthropods, on the other hand, have scored their greatest successes on land, with the spiders and especially the insects. Yet the fossil record reveals a lack of all advance, even in the most successful types such as ants, for a long time back – certainly during the last thirty million years, probably during the whole of the Tertiary epoch. Even during the shorter of these periods, the mammals were still evolving rapidly, and man's rise is contained in a fraction of this time.

What was it that cut the insects off from progress? The answer appears to lie in their breathing mechanism. The land arthropods have adopted the method of air-tubes or tracheae, branching to microscopic size and conveying gases directly to and from the tissues, instead of using the dual mechanism of lungs and bloodstream. The laws of gaseous diffusion are such that respiration by tracheæ is extremely efficient for very small animals, but becomes rapidly less efficient with increase of size, until it ceases to be of use at a bulk below that of a house mouse. It is for this reason that no insect has ever become, by vertebrate standards, even moderately large.

It is for the same reason that no insect has ever become even moderately intelligent. The fixed pathways of instinct, however elaborate, require far fewer nerve-cells than the multiple switchboards that underlie intelligence. It appears to be impossible to build a brain mechanism for flexible behaviour with less than a quite large minimum of neurons; and no insect has reached a size to provide this minimum.

Thus only the land vertebrates are left. The reptiles shared biological dominance with the insects in the Mesozoic. But while the insects had reached the end of their blind alley, the reptiles showed themselves capable of further advance. Temperature regulation is a necessary basis for final progress, since without it the rate of bodily function could never be stabilized, and without such stabilization, higher mental processes could never become accurate and dependable.

Two reptilian lines achieved this next step, in the guise of the birds and the mammals. The birds soon, however, came to a dead end, chiefly because their forelimbs were entirely taken up in the specialization for flight. The subhuman mammals made another fundamental advance, in the shape of internal development, permitting the young animal to arrive at a much more advanced stage before it was called upon to face the world. They also (like the birds) developed true family life.

Most mammalian lines, however, cut themselves off from indefinite progress by one-sided evolution, turning their limbs and jaws into specialized and therefore limited instruments. And, for the most part, they relied mainly on the crude sense of smell, which cannot present as differentiated a pattern of detailed knowledge as can sight. Finally, the majority continued to produce their young several at a time, in litters. As J. B. S. Haldane has pointed out, this gives rise to an acute struggle for existence in the prenatal period, a considerable percentage of embryos being aborted or resorbed. Such intra-uterine selection will put a premium upon rapidity of growth and differentiation, since the devil takes the hindmost; and this rapidity of development will tend automatically to be carried on into postnatal growth.

As everyone knows, man is characterized by a rate of development which is abnormally slow as compared with that of any other mammal. The period from birth to the first onset of sexual maturity comprises nearly a quarter of the normal span of his life, instead of an eighth, a tenth or twelfth, as in some other animals. This again is in one sense a unique characteristic of man, although from the evolutionary point of view it represents merely the exaggeration of a tendency which is operative in other Primates. In any case, it is a necessary condition for the evolution and proper utilization of rational thought. If men and women were, like mice, confronted with the problems of adult life and parenthood after a few weeks, or even, like whales, after a couple of years, they could never acquire the skills of body and mind that they now absorb from and contribute to the social heritage of the species.

This slowing (or "foetalization", as Bolk has called it, since it prolongs the foetal characteristics of earlier ancestral forms into postnatal development and even into adult life) has had other important by-products for man. Here I will mention but one – his nakedness. The distribution of hair on man is extremely similar to that on a late foetus of a chimpanzee, and there can be little doubt that it represents an extension of this temporary anthropoid phase into permanence. Hairlessness of body is not a unique biological characteristic of man; but it is unique among terrestrial mammals, save for a few desert creatures, and some others which have compensated for loss of hair by developing a pachydermatous skin. In any case, it has important biological consequences, since it must have encouraged the comparatively defenseless human creatures in their efforts to protect themselves against animal enemies and the elements, and so has been a spur to the improvement of intelligence.

Now, foetalization could never have occurred in a mammal producing many young at a time, since intra-uterine competition would have encouraged the opposing tendency. Thus we may conclude that conceptual thought could develop only in a mammalian stock which normally brings forth but one young at a birth. Such a stock is provided in the Primates – lemurs, monkeys, and apes.

The Primates also have another characteristic which was necessary for the ancestor of a rational animal – they are arboreal. It may seem curious that living in trees is a prerequisite of conceptual thought. But Elliot Smith's analysis has abundantly shown that only in an arboreal mammal could the forelimb become a true hand, and sight become dominant over smell. Hands obtain an elaborate tactile pattern of what they handle, eyes an elaborate visual pattern of what they see. The combination of the two kinds of pattern, with the aid of binocular vision, in the higher centres of the brain allowed the Primate to acquire a wholly new richness of knowledge about objects, a wholly new possibility of manipulating them. Tree life laid the foundation both for the fuller definition of objects by conceptual thought and for the fuller control of them by tools and machines.

Higher Primates have yet another pre-requisite of human intelligence – they are all gregarious. Speech, it is obvious, could never have been evolved in a solitary type. And speech is as much the physical basis of conceptual thought as is protoplasm the physical basis of life.

For the passage, however, of the critical point between sub-human and human, between the biological subordination and the biological primacy of intelligence, between a limited and a potentially unlimited tradition–for this it was necessary for the arboreal animal to descend to the ground again. Only in a terrestrial creature could fully erect posture be acquired; and this was essential for the final conversion of the arms from locomotor limbs into manipulative hands. Furthermore, just as land life, ages previously, had demanded and developed a greater variety of response than had been required in the water, so now it did the same in relation to what had been required in the trees. An arboreal animal could never have evolved the skill of the hunting savage, nor ever have proceeded to the domestication of other animals or to agriculture.

We are now in a position to define the uniqueness of human evolution. The essential character of man as a dominant organism is conceptual thought. And conceptual thought could have arisen only in a multicellular animal, an animal with bilateral symmetry, head and blood system, a vertebrate as against a mollusc or an arthropod, a land vertebrate among vertebrates, a mammal among land vertebrates. Finally, it could have arisen only in a mammalian line which was gregarious, which produced one young at a birth instead of several, and which had recently become terrestrial after a long period of arboreal life.

There is only one group of animals which fulfils these conditions–a terrestrial offshoot of the higher Primates.

Thus not merely has conceptual thought been evolved only in man: it could not have been evolved except in man. There is but one path of unlimited progress through the evolutionary maze. The course of human evolution is as unique as its result. It is unique not in the trivial sense of being a different course from that of any other organism, but in the profounder sense of being the only path that could have achieved the essential characters of man. Conceptual thought on this planet is inevitably associated with a particular type of Primate body and Primate brain.

A further property of man in which he is unique among higher animals concerns his sexual life. Man is prepared to mate at any time; animals are not. To start with, most animals have a definite breeding season; only during this period are their reproductive organs fully developed and functional. In addition to this, higher animals have one or more sexual cycles within their breeding seasons, and only at one phase of the cycle are they prepared to mate. In general, either a sexual season or a sexual cycle, or both, operates to restrict mating.

In man, however, neither of these factors is at work. There appear to be indications of a breeding season in some primitive peoples like the Eskimo, but even there they are but relics. Similarly, while there still exist physiological differences in sexual desire at different phases of the female sexual cycle, these are purely quantitative, and may readily be over-ridden by psychological factors. Man, to put it briefly, is continuously sexed: animals are discontinuously sexed. If we try to imagine what a human society would be like in which the sexes were interested in each other only during the summer, as in songbirds, or, as in female dogs, experienced sexual desire only once every few months, or even only once in a lifetime, as in ants, we can realize what this peculiarity has meant. In this, as in his slow growth and prolonged period of dependence, man is not abruptly marked off from all other animals, but represents the culmination of a process that can be clearly traced among other Primates. What the biological meaning of this evolutionary trend may be is difficult to understand. One suggestion is that it may be associated with the rise of mind to dominance. The bodily functions, in lower mammals rigidly determined by physiological mechanisms, come gradually under the more plastic control of the brain. But this, for what it is worth, is a mere speculation.

Another of the purely biological characters in which man is unique is his reproductive variability. In a given species of animals, the maximum litter-size may, on occasions, reach perhaps double the minimum, according to circumstances of food and temperature, or even perhaps threefold. But during a period of years, these variations will be largely equalized within a range of perhaps fifty per cent either way from the average, and the percentage of wholly infertile adults is very low. In man, on the other hand, the range of positive fertility is enormous—from one to over a dozen, and in exceptional cases to over twenty; and the number of wholly infertile adults is considerable. This fact, in addition to providing a great diversity of patterns of family life, has important bearings on evolution. It means that in the human species differential fertility is more important as a basis for selection than is differential mortality; and it provides the possibility of much more rapid selective change than that found in wild animal species. Such rapidity of evolution would, of course, be effectively realized only if the stocks with large families possessed a markedly different hereditary constitution from those with few children; but the high differential fertility of unskilled workers as against the professional classes in England, or of the French Canadian against the rest of the inhabitants of Canada, demonstrates how rapidly populations may change by this means.

Still another point in which man is biologically unique is the length and relative importance of his period of what we may call "post-maturity." If we consider the female sex, in which the transition from reproductive maturity to non-reproductive post-maturity is more sharply defined than in the male, we find, in the first place, that in animals a comparatively small percentage of the population survives beyond the period of reproduction; in the second place, that such individuals rarely survive long, and so far as known never for a period equal to or greater than the period during which reproduction was possible; and thirdly, that such individuals are rarely of importance in the life of the species. The same is true of the male sex, provided we do not take the incapacity to produce fertile gametes as the criterion of post-maturity, but rather the appearance of signs of age, such as the beginnings of loss of vigour and weight, decreased sexual activity, or greying hair.

It is true that in some social mammals, notably among Ruminants and Primates, an old male or old female is frequently found as leader of the herd. Such cases, however, provide the only examples of the special biological utility of post-mature individuals among animals; they are confined to a very small proportion of the population, and it is uncertain to what extent such individuals are post-mature in the sense we have defined. In any event, it is improbable that the period of post-maturity is anywhere near so long as that of maturity. But in civilized man the average expectation of life now includes over ten post-mature years, and about a sixth of the population enjoys a longer post-maturity than maturity. What is more, in all advanced human societies a larger proportion of the leaders of the community are always post-mature. All the members of the British War Cabinet are post-mature.

This is truly a remarkable phenomenon. Through the new social mechanisms made possible by speech and tradition, man has been able to utilize for the benefit of the species a period of life which in almost all other creatures is a mere superfluity. We know that the dominance of the old can be over-emphasized; but it is equally obvious that society cannot do without the post-mature. To act on the slogan "Too old at forty" – or even at forty-five – would be to rob man of one of his unique characteristics, whereby he utilizes tradition to the best advantages.

We have now dealt in a broad way with the unique properties of man both from the comparative and the evolutionary point of view. Now we can return to the present and the particular and discuss these properties and their consequences a little more in detail. First, let us remind ourselves that the gap between human and animal thought is much greater than is usually supposed. The tendency to project familiar human qualities into animals is very strong, and colours the ideas of nearly all people who have not special familiarity both with animal behaviour and scientific method.

Let us recall a few cases illustrating the unhuman characteristics of animal behaviour. Everyone is familiar with the rigidity of instinct in insects. Worker ants emerge from their pupal case equipped not with the instincts to care for ant grubs in general, but solely with those suitable to ant grubs of their own species. They will attempt to care for the grubs of other species, but appear incapable of learning new methods if their instincts kill their foster children. Or again, a worker wasp, without food for a hungry grub, has been known to bite off its charge's tail and present it to its head. But even in the fine flowers of vertebrate evolution, the birds and mammals, behaviour, though it may be more plastic than in the insects, is as essentially irrational. Birds, for instance, seem incapable of analysing unfamiliar situations. For them some element in the situation may act as its dominant symbol, the only stimulus to which they can react. At other times, it is the organization of the situation as a whole which is the stimulus: if the whole is interfered with, analysis fails to dissect out the essential element. A hen meadow-pipit feeds her young when it gapes and squeaks in the nest. But if it has been ejected by a young cuckoo, gaping and squeaking has no effect, and the rightful offspring is neglected and allowed to die, while the usurper in the nest is fed. The pipit normally cares for its own young, but not because it recognizes them as such.

Mammals are no better. A cow deprived of its calf will be quieted by the provision of a crudely stuffed calfskin. Even the Primates are no exception. Female baboons whose offspring have died will continue carrying the corpses until they have not merely putrefied but mummified. This appears to be due not to any profundity of grief, but to a contact stimulus: the mother will react similarly to any moderately small and furry object.

Birds and especially mammals are, of course, capable of a certain degree of analysis, but this is effected, in the main, by means of trial and error through concrete experience. A brain capable of conceptual thought appears to be the necessary basis for speedy and habitual analysis. Without it, the practice of splitting up situations into their components and assigning real degrees of significance to the various elements remains rudimentary and rare, whereas with man, even when habit and trial and error are prevalent, conceptual thought is of major biological importance. The behaviour of animals is essentially arbitrary, in that it is fixed within narrow limits. In man it has become relatively free – free at the incoming and outgoing ends alike. His capacity for acquiring knowledge has been largely released from arbitrary symbolism, his capacity for action, from arbitrary canalizations of instinct. He can thus rearrange the patterns of experience and action in a far greater variety, and can escape from the particular into the general.

Thus man is more intelligent than the animals because his brain mechanism is more plastic. This fact also gives him, of course, the opportunity of being more nonsensical and perverse: but its primary effects have been more analytical knowledge and more varied control. The essential fact, from my present standpoint, is that the change has been profound and in an evolutionary sense rapid. Although it has been brought about by the gradual quantitative enlargement of the association areas of the brain, the result has been almost as abrupt as the change (also brought about quantitatively) from solid ice to liquid water. We should remember that the machinery of the change has been an increase in plasticity and potential variety: it is by a natural selection of ideas and actions that the result has been greater rationality instead of greater irrationality.

This increase of flexibility has also had other psychological consequences which rational philosophers are apt to forget: and in some of these, too, man is unique. It has led, for instance, to the fact that man is the only organism normally and inevitably subject to psychological conflict. You can give a dog neurosis, as Pavlov did, by a complicated laboratory experiment: you can find cases of brief emotional conflict in the lives of wild birds and animals. But, for the most part, psychological conflict is shirked by the simple expedient of arranging that now one and now another instinct should dominate the animal's behaviour. I remember in Spitsbergen finding the nest of a Red-throated Diver on the shore of an inland pool. The sitting bird was remarkably bold. After leaving the nest for the water, she stayed very close. She did not, however, remain in a state of conflict between fear of intruders and desire to return to her brooding. She would gradually approach as if to land, but eventually fear became dominant, and when a few feet from the shore she suddenly dived, and emerged a good way farther out – only to repeat the process. Here the external circumstances were such as to encourage conflict, but even so what are the most serious features of human conflict were minimized by the outlet of alternate action.

Those who take up bird-watching as a hobby tend at first to be surprised at the way in which a bird will turn, apparently without transition or hesitation, from one activity to another–from fighting to peaceable feeding, from courtship to uninterested preening, from panic flight to unconcern. However, all experienced naturalists or those habitually concerned with animals recognize such behaviour as characteristic of the subhuman level. It represents another aspect of the type of behaviour I have just been describing for the Red-throated Diver. In this case, the internal state of the bird changes, presumably owing to some form of physiological fatigue or to a diminution of intensity of a stimulus with time or distance; the type of behaviour which had been dominant ceases to have command over the machinery of action, and is replaced by another which just before had been subordinate and latent.

As a matter of fact, the prevention of conflict between opposed modes of action is a very general phenomenon, of obvious biological utility, and it is only the peculiarities of the human mind which have forced its partial abandonment on man. It begins on the purely mechanical level with the nervous machinery controlling our muscles. The main muscles of a limb, for instance, are arranged in two antagonistic sets, the flexors bending and the extensors straightening it. It would obviously be futile to throw both sets into action at the same time, and economical when one set is in action to reduce to the minimum any resistance offered by the other. This has actually been provided for. The nervous connections in the spinal cord are so arranged that when a given muscle receives an impulse to contract, its antagonist receives an impulse causing it to lose some of its tone and thus, by relaxing below its normal level, to offer the least possible resistance to the action of the active muscle.

Sherrington discovered that the same type of mechanism was operative in regard to the groups of muscles involved in whole reflexes. A dog, for instance, cannot very well bark and scratch itself at the same time. To avoid the waste involved in conflict between the walking and the scratching reflex, the spinal cord is constructed in such a way that throwing one reflex into action automatically inhibits the other. In both these cases, the machinery for preventing conflicts of activity resides in the spinal cord. Although the matter has not yet been analysed physiologically, it would appear that the normal lack of conflict between instincts which we have just been discussing is due to some similar type of nervous mechanism in the brain.

When we reach the human level, there are new complications; for, as we have seen, one of the peculiarities of man is the abandonment of any rigidity of instinct, and the provision of association-mechanisms by which any activity of the mind, whether in the spheres of knowing, feeling, or willing, can be brought into relation with any other. It is through this that man has acquired the possibility of a unified mental life. But, by the same token, the door is opened to the forces of disruption, which may destroy any such unity and even prevent him from enjoying the efficiency of behaviour attained by animals. For, as Sherrington has emphasized, the nervous system is like a funnel, with a much larger space for intake than for outflow. The intake cone of the funnel is represented by the receptor nerves, conveying impulses inward to the central nervous system from the sense-organs: the outflow tube is, then, through the effector nerves, conveying impulses outward to the muscles, and there are many more of the former than of the latter. If we like to look at the matter from a rather different standpoint, we may say that, since action can be effected only by muscles (strictly speaking, also by the glands, which are disregarded here for simplicity's sake), and since there are a limited number of muscles in the body, the only way for useful activity to be carried out is for the nervous system to impose a particular pattern of action on them, and for all other competing or opposing patterns to be cut out. Each pattern, when it has seized control of the machinery of action, should be in supreme command, like the captain of a ship. Animals are, in many ways, like ships which are commanded by a number of captains in turn, each specializing in one kind of action, and popping up and down between the authority of the bridge and the obscurity of their private cabins according to the business on hand. Man is on the way to achieving permanent unity of command, but the captain has a disconcerting way of dissolving into a wrangling committee.

Even on the new basis, however, mechanisms exist for minimizing conflict. They are what are known by psychologists as suppression and repression. From our point of view, repression is the more interesting. It implies the forcible imprisonment of one of two conflicting impulses in the dungeons of the unconscious mind. The metaphor is, however, imperfect. For the prisoner in the mental dungeon can continue to influence the tyrant above in the daylight of consciousness. In addition to a general neurosis, compulsive thoughts and acts may be thrust upon the personality. Repression may thus be harmful; but it can also be regarded as a biological necessity for dealing with inevitable conflict in the early years of life, before rational judgment and control are possible. Better to have the capacity for more or less unimpeded action, even at the expense of possible neurosis, than an organism constantly inactivated like the ass between the two bundles of hay, balanced in irresolution.

In repression, not only is the defeated impulse banished to the unconscious, but the very process of banishment is itself unconscious. The inhibitory mechanisms concerned in it must have been evolved to counteract the more obvious possibilities of conflict, especially in early life, which arose as by-products of the human type of mind.

In suppression, the banishment is conscious, so that neurosis is not likely to appear. Finally, in rational judgment, neither of the conflicting impulses is relegated to the unconscious, but they are balanced in the light of reason and experience, and control of action is consciously exercised.

I need not pursue the subject further. Here I am only concerned to show that the great biological advantages conferred on man by the unification of mind have inevitably brought with them certain counterbalancing defects. The freedom of association between all aspects and processes of the mind has provided the basis for conceptual thought and tradition; but it has also provided potential antagonists, which in lower organisms were carefully kept apart, with the opportunity of meeting face to face, and has thus made some degree of conflict unavoidable.

In rather similar fashion, man's upright posture has brought with it certain consequential disadvantages in regard to the functioning of his internal organs and his proneness to rupture. Thus man's unique characteristics are by no means wholly beneficial.

In close correlation with our subjection to conflict is our proneness to laughter. So characteristic of our species is laughter that man has been defined as the laughing animal. It is true that, like so much else of man's uniqueness, it has its roots among the animals, where it reveals itself as an expression of a certain kind of general pleasure—and thus in truth perhaps more of a smile than a laugh. And in a few animals – ravens, for example, – there are traces of a malicious sense of humour. Laughter in man, however, is much more than this. There are many theories of laughter, most of them containing a partial truth. But biologically the important feature of human laughter seems to lie in its providing a release for conflict, a resolution of troublesome situations.

This and other functions of laughter can be exaggerated so that it becomes as the crackling of thorns under the pot, and its value is very great as a lubricant against troublesome friction and a lightener of the inevitable gravity and horror of life, which would otherwise become portentous and overshadowing. True laughter, like true speech, is a unique possession of man.

Those of man's unique characteristics which may better be called psychological and social than narrowly biological spring from one or the other of three characteristics. The first is his capacity for abstract and general thought: the second is the relative unification of his mental processes, as against the much more rigid compartmentalization of animal mind and behaviour: the third is the existence of social units, such as tribe, nation, party, and church, with a continuity of their own, based on organized tradition and culture.

There are various by-products of the change from pre-human to the human type of mind which are, of course, also unique biologically. Let us enumerate a few: pure mathematics; musical gifts; artistic appreciation and creation; religion; romantic love.

Mathematical ability appears, almost inevitably, as something mysterious. Yet the attainment of speech, abstraction, and logical thought, bring it into potential being. It may remain in a very rudimentary state of development; but even the simplest arithmetical calculations are a manifestation of its existence. Like any other human activity, it requires proper tools and machinery. Arabic numerals, algebraic conventions, logarithms, the differential calculus, are such tools: each one unlocks new possibilities of mathematical achievement. But just as there is no essential difference between man's conscious use of a chipped flint as an implement and his design of the most elaborate machine, so there is none between such simple operations as numeration or addition and the comprehensive flights of higher mathematics. Again, some people are by nature more gifted than others in this field; yet no normal human being is unable to perform some mathematical operations. Thus the capacity for mathematics is, as I have said, a by-product of the human type of mind.

We have seen, however, that the human type of mind is distinguished by two somewhat opposed attributes. One is the capacity for abstraction, the other for synthesis. Mathematics is one of the extreme by-products of our capacity for abstraction. Arithmetic abstracts objects of all qualities save their enumerability; the symbol π abstracts in a single Greek letter a complicated relation between the parts of all circles. Art, on the other hand, is an extreme by-product of our capacity for synthesis. In one unique production, the painter can bring together form, colour, arrangement, associations of memory, emotion, and idea. Dim adumbrations of art are to be found in a few creatures such as bower-birds; but nothing is found to which the word can rightly be applied until man's mind gave the possibility of freely mingling observations, emotions, memories, and ideas, and subjecting the mixture to deliberate control.

But it is not enough here to enumerate a few special activities. In point of fact, the great majority of man's activities and characteristics are by-products of his primary distinctive characteristics, and therefore, like them, biologically unique.

On the one hand, conversation, organized games, education, sport, paid work, gardening, the theatre; on the other, conscience, duty, sin, humiliation, vice, penitence—these are all such unique by-products. The trouble, indeed, is to find any human activities which are not unique. Even the fundamental biological attributes such as eating, sleeping and mating have been tricked out by man with all kinds of unique frills and peculiarities.

There may be other by-products of man's basic uniqueness which have not yet been exploited. For let us remember that such by-products may remain almost wholly latent until demand stimulates invention and invention facilitates development. It is asserted that there exist human tribes who cannot count above two; certainly some savages stop at ten. Here the mathematical faculty is restricted to numeration, and stops short at a very rudimentary stage of this rudimentary process. Similarly, there are human societies in which art has never been developed beyond the stage of personal decoration. It is probable that during the first half of the Pleistocene period, none of the human race had developed either their mathematical or their artistic potentialities beyond such a rudimentary stage.

It is perfectly possible that to-day man's so-called supernormal or extra-sensory faculties are in the same case as were his mathematical faculties during the first or second glaciations of the Ice Age – barely more than a potentiality, with no technique for eliciting and developing them, no tradition behind them to give them continuity and intellectual respectability. Even such simple performances as multiplying two three-figure numbers would have appeared entirely magical to early Stone Age men.

Experiments such as those of Rhine and Tyrrell on extra-sensory guessing, experiences like those of Gilbert Murray on thought transference, and the numerous sporadic records of telepathy and clairvoyance suggest that some people at least possess possibilities of knowledge which are not confined within the ordinary channels of sense-perception. Tyrrell's work is particularly interesting in this connection. As a result of an enormous number of trials with apparatus ingeniously designed to exclude all alternative explanation, he finds that those best endowed with this extra-sensory gift can guess right about once in four times when once in five would be expected on chance alone. The results are definite, and significant in the statistical sense, yet the faculty is rudimentary: it does not permit its possessor to guess right all the time or even most of the time — merely to achieve a small rise in the percentage of right guessing. If, however, we could discover in what this faculty really consists, on what mechanism it depends, and by what conditions and agencies it can be influenced, it should be capable of development like any other human faculty. Man may thus be unique in more ways than he now suspects.

So far we have been considering the fact of human uniqueness. It remains to consider man's attitude to those unique qualities of his. Professor Everett, of the University of California, in an interesting paper bearing the same title as this essay, but dealing with the topic from the standpoint of the philosopher and the humanist rather than that of the biologist, has stressed man's fear of his own uniqueness. Man has often not been able to tolerate the feeling that he inhabits an alien world, whose laws do not make sense in the light of his intelligence, and in which the writ of his human values does not run. Faced with the prospect of such intellectual and moral loneliness, he has projected personality into the cosmic scheme. Here he has found a will, there a purpose; here a creative intelligence, and there a divine compassion. At one time, he has deified animals, or personified natural forces. At others, he has created a superhuman pantheon, a single tyrannical world ruler, a subtle and satisfying Trinity in Unity. Philosophers have postulated an Absolute of the same nature as mind.

It is only exceptionally that men have dared to uphold their uniqueness and to be proud of their human superiority to the impersonality and irrationality of the rest of the universe. It is time now, in the light of our knowledge, to be brave and face the fact and the consequences of our uniqueness. That is Dr. Everett's view, as it was also that of T. H. Huxley in his famous Romanes lecture. I agree with them; but I would suggest that the antinomy between man and the universe is not quite so sharp as they have made out. Man represents the culmination of that process of organic evolution which has been proceeding on this planet for over a thousand million years. That process, however wasteful and cruel it may be, and into however many blind alleys it may have been diverted, is also in one aspect progressive. Man has now become the sole representative of life in that progressive aspect and its sole trustee for any progress in the future.

Meanwhile it is true that the appearance of the human type of mind, the latest step in evolutionary progress, has introduced both new methods and new standards. By means of his conscious reason and its chief offspring, science, man has the power of substituting less dilatory, less wasteful, and less cruel methods of effective progressive change than those of natural selection, which alone are available to lower organisms. And by means of his conscious purpose and his set of values, he has the power of substituting new and higher standards for change than those of mere survival and adaptation to immediate circumstances which alone are inherent in pre-human evolution. To put the matter in another way, progress has hitherto been a rare and fitful by-product of evolution. Man has the possibility of making it the main feature of his own future evolution, and of guiding its course in relation to a deliberate aim.

But he must not be afraid of his uniqueness. There may be other beings in this vast universe endowed with reason, purpose, and aspiration: but we know nothing of them. So far as our knowledge goes, human mind and personality are unique and constitute the highest product yet achieved by the cosmos. Let us not put off our responsibilities on to the shoulders of mythical gods or philosophical absolutes, but shoulder them in the hopefulness of tempered pride. In the perspective of biology, our business in the world is seen to be the imposition of the best and most enduring of our human standards upon ourselves and our planet. The enjoyment of beauty and interest, the achievement of goodness and efficiency, the enhancement of life and its variety—these are the harvest which our human uniqueness should be called upon to yield.

[From *THE UNIQUENESS OF MAN*, Chatto and Windus, London, 1941, pp. 1-33]

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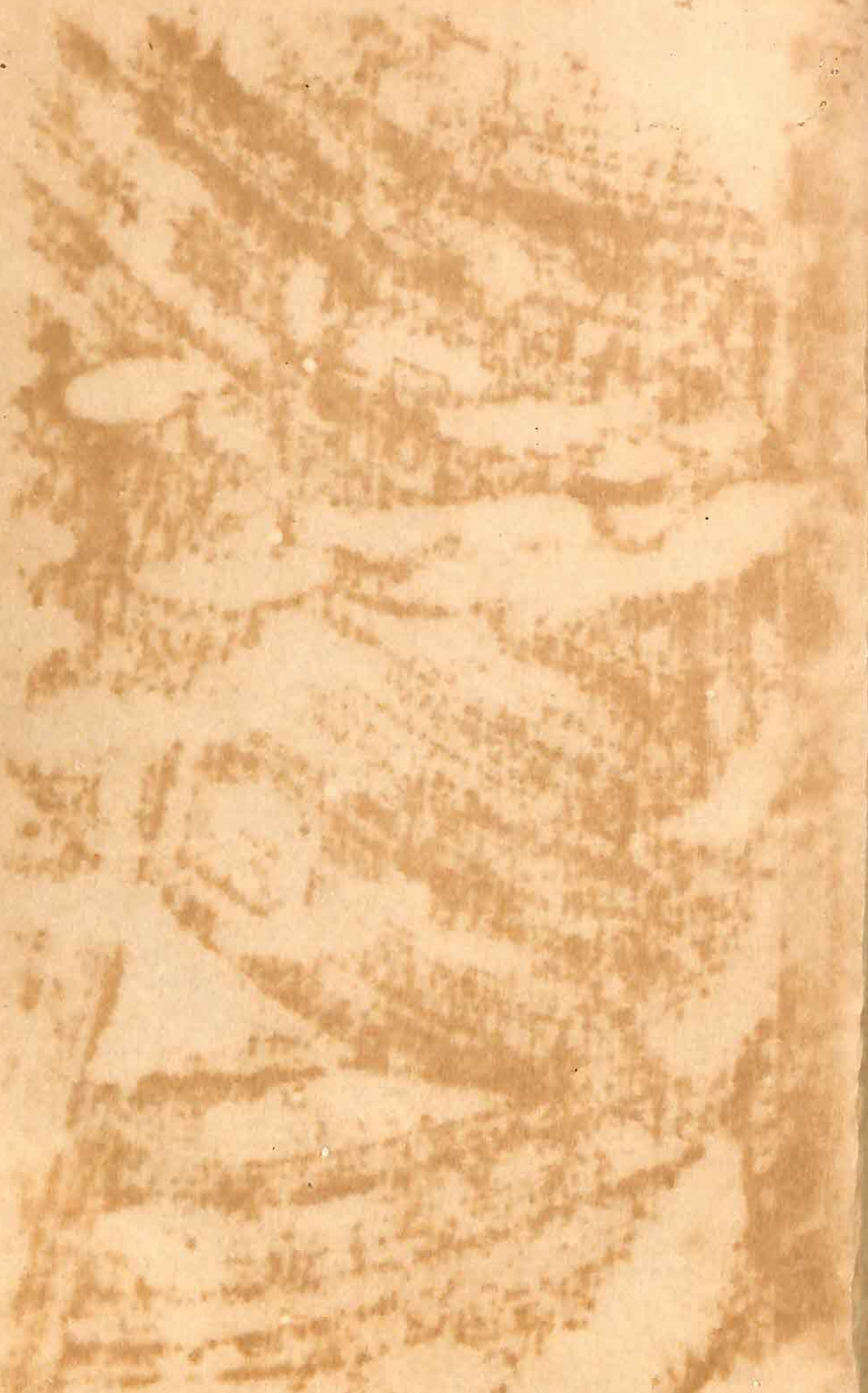

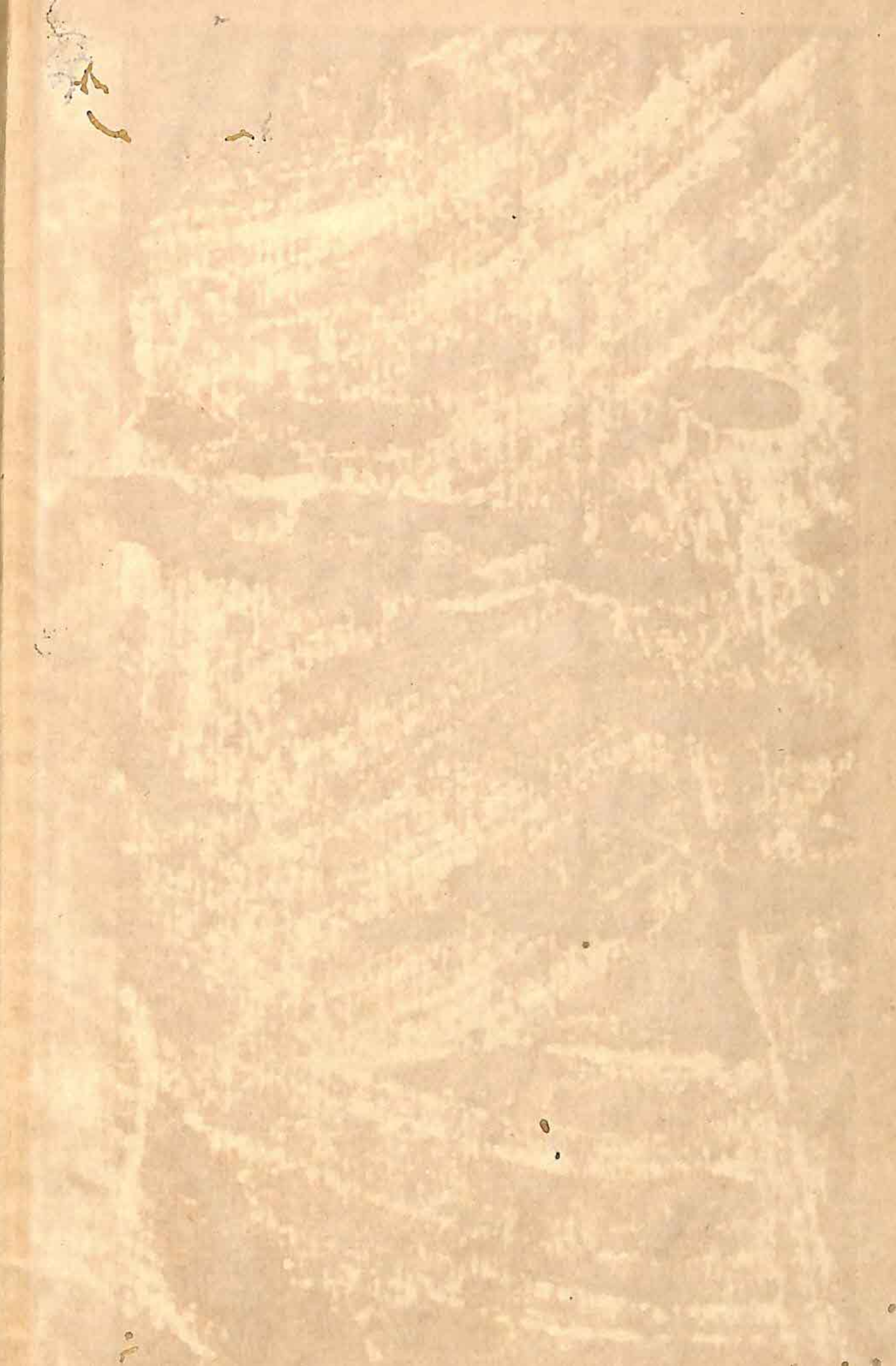

Significant Writings on Life and Man

As far back as human memory goes, man has assumed the fact of his uniqueness in the scheme of things. Traditional religions and modes of thought supported the postulate that man was some sort of a special and superior act of creation—the lord and master of everything on earth. Darwin (1809-82) threw the first formidable bombshell on this smug complacency by linking man to apes and making all life kin; all organic nature was a unity in diversity.

Academician Alexander Oparin, Director of the Institute of Biochemistry of the Soviet Academy of Science, went a step further and pioneered the study of the origin of life; "how, when and where dead matter changed into living matter." This was another blow to the picture of man's uniqueness, for it destroyed the clear-cut demarcation between life and non-life. J. B. S. Haldane's researches into certain types of birds and flies dispelled the traditional picture of man's superiority still further, for these organisms too were discovered to have a number of institutions and observances which at one time were considered unique to man—song, dance and courtship, monogamy and widowhood, and in some cases, even languages adequate to their needs.

But scientific research which abolished the traditional and religious uniqueness of man, however, recognized a new and more substantial uniqueness much nearer facts for him—uniqueness in the realm of thought. Man, consider modern scientists, is still unique—in his capacity for conceptual thought, his employment of speech and the development of cumulative tradition. All this, they maintain, will progressively improve his tools and techniques and will forever ensure that he lords over other organisms, that he is the crown of creation. Julian Huxley recognizes that Man as *Homo Sapiens* should discharge his duties "in the hopefulness of tempered pride." This completes the circle of thought about man's uniqueness from the beginning of time to the 20th Century, which is the theme of this anthology.

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